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United States Patent [19]

Rousseau et al.

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[45] Date of Patent: Oct. 31, 2000

[54] **RADIOTELECOMMUNICATIONS SYSTEM HAVING A MOBILE TERMINAL THAT OPERATES BOTH IN CELLULAR MODE AND IN CORDLESS MODE**

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[73] Assignee: **Alcatel**, Paris, France

[21] Appl. No.: **09/114,499**

[22] Filed: **Jul. 13, 1998**

[30] **Foreign Application Priority Data**

Jul. 17, 1997 [FR] France 97 09068

[51] **Int. Cl.**[7] **H04Q 7/20**

[52] **U.S. Cl.** **455/426**; 455/552; 455/462; 455/447; 455/437; 455/417

[58] **Field of Search** 455/552, 553, 455/462, 463, 464, 426, 454, 447, 466

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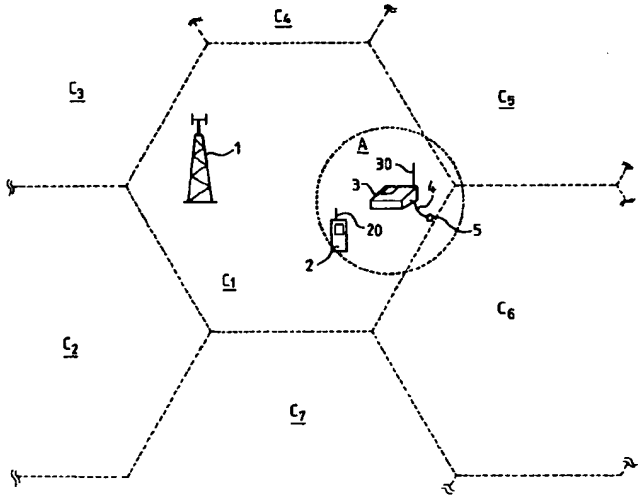
Primary Examiner—Daniel S. Hunter
Assistant Examiner—Yemane Woldetatios
Attorney, Agent, or Firm—Sughrue, Mion, Zinn, Macpeak & Seas, PLLC

[57] **ABSTRACT**

The invention relates to a radiotelecommunications system having a mobile terminal equipped with a subscriber identity module and designed to operate in a cellular network having a plurality of cells. The system has a private base station independent from the cellular network and connected to a wired telecommunications network. The private base station occupies at least a part of one of the cells of the cellular network, to which cell the cellular network has allocated at least one frequency from among all of the frequencies available in the cellular network; if it is situated within a zone close to the private base station, the mobile terminal can operate in cordless mode, in which it communicates with the wired network by communicating by radio with the private base station, radio communication taking place on at least one frequency selected from a predetermined set of one or more frequencies chosen from among all of the frequencies available in the cellular network except at least those frequencies which are allocated to said cell, the set of frequencies being pre-recorded in the subscriber identity module or in a memory zone of the terminal. According to the invention, said set of frequencies is transmitted to the mobile terminal by radio from a base station of the cellular network.

9 Claims, 2 Drawing Sheets



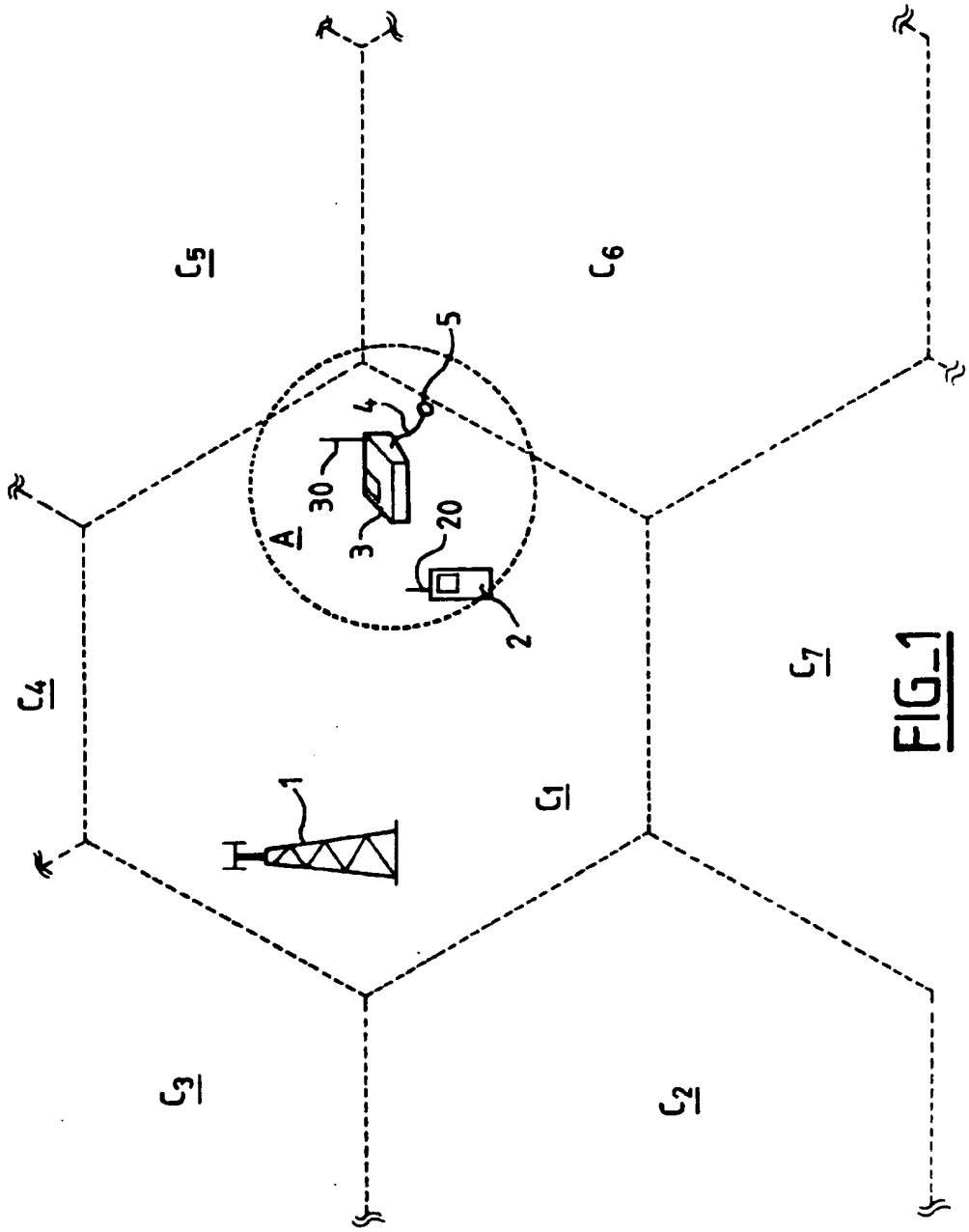
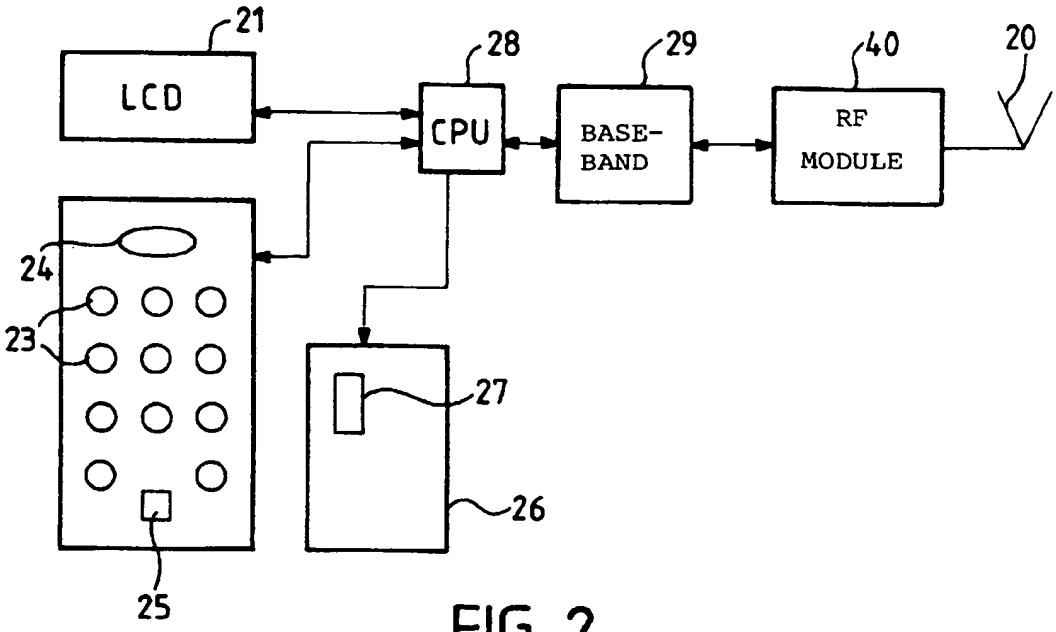


FIG_1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LCD
28
CPU
29
BASE-
BAND
40
RF
MODULE
20
24
23
27
26
25

FIG_2

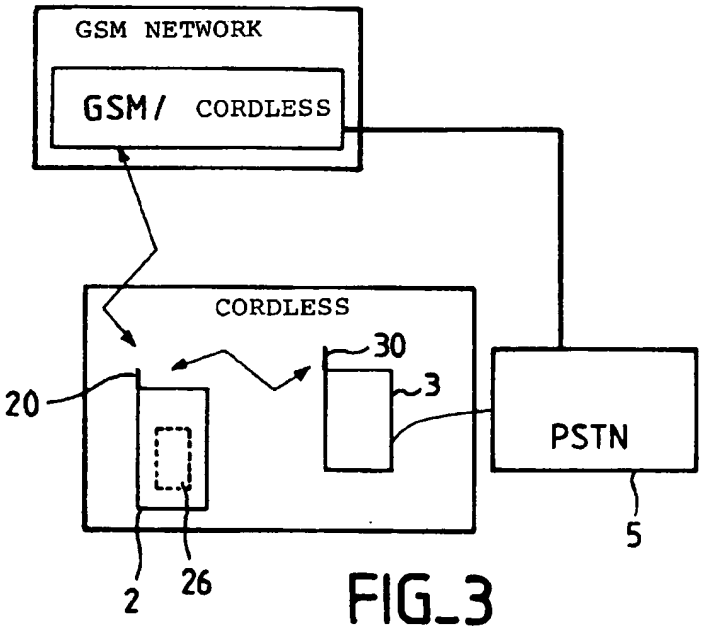
GSM NETWORK
GSM/ CORDLESS
CORDLESS
30
3
20
PSTN
5
2
26

FIG_3

RADIOTELECOMMUNICATIONS SYSTEM HAVING A MOBILE TERMINAL THAT OPERATES BOTH IN CELLULAR MODE AND IN CORDLESS MODE

The present invention relates to a radiotelecommunications system having a mobile terminal provided with a subscriber identity module and designed to operate in a first mode, referred to as "cellular mode" in a cellular network having a plurality of cells.

BACKGROUND OF THE INVENTION

The main purpose of a cellular network, e.g. a digital network using a standardized system such as the Global System for Mobile communications (GSM), the Digital Cellular System (DCS), or the Personal Communication System (PCS) 1900, is to convey a call by radio on a carrier frequency between a base station of the network and a mobile terminal of a user who is a subscriber to the network. Each cellular network is allocated a certain range of frequencies, which range is restricted compared with all of the frequencies that are useable in the system in question. By way of example, GSM has 125 possible carrier frequencies, and, in France, most of them are shared between two main operators, each owning a respective digital cellular network.

Furthermore, the territory covered by any given cellular network is subdivided into cells, each cell generally having a base station suitable for communicating with all of the mobile terminals that are situated in the cell at any given time. A well-known subdivision configuration given by way of example consists in choosing cells that are ideally adjacent, of the same size, and hexagonal in shape. It is thus possible to define a particular set of cells, referred to as a "pattern", e.g. a seven-cell pattern constituted by a central cell surrounded by six adjacent cells.

Moreover, the base stations and the mobile terminals of a cellular network are of limited range, i.e. beyond a certain distance, communication is no longer possible because of the attenuation of the carrier frequency. It is thus possible for the same carrier frequency to be used in different places provided that these places are far enough apart. This is particularly important because, as indicated above, each network possesses only a limited number of carrier frequencies for an ever increasing number of subscribers. Thus, each cellular network defines a scheme for re-using frequencies, and, by way of example, reference may be made to the above-mentioned seven-cell pattern. In such a pattern, different carrier frequencies are allocated to each cell, each cell being allocated one or more carrier frequencies. The pattern is repeated by shifting such that, for any given cell in the initial pattern, there are six closest neighboring cells that reuse the same frequencies, and these cells are uniformly distributed on a circle whose center coincides with the center of the given cell.

The boom in mobile telephones is such that a large and ever-increasing number of private individuals presently possess mobile terminals. Among these users, who are attracted by the concept of being able to communicate with a high degree of freedom, many also have a cordless telephone in their own home or might subsequently procure such a telephone which enables them to be on the phone while being free to move in a zone close to a fixed station in the home, the cordless telephone communicating with said station by radio, the station itself being connected by wire to a wired telecommunications network, e.g. a network of the Public Switched Telephone Network (PSTN) type.

OBJECTS AND SUMMARY OF THE INVENTION

The basic concept of the present invention lies in the fact that it would, undeniably, be advantageous for the user to have a single portable telephone set which could operate not only in "cellular" mode, i.e. via a cellular network to which the user subscribes, but also in "cordless" mode whenever the user is in a predetermined zone, in particular either at home or at work.

An object of the present invention is thus to provide a radiotelecommunications system having a mobile terminal designed to operate both in a "cellular" first mode in a digital cellular network, and in a "cordless" second mode.

There are several problems to be solved to achieve this object:

- Firstly, it is necessary to allocate to the mobile terminal one or more frequencies that can be used in the cordless second mode only, so as to enable the mobile terminal to communicate by radio with a private station connected to a wired telecommunications network. These frequencies must be frequencies of the cellular system if it is to be possible to use existing mobile terminals. Furthermore the frequencies must be frequencies of the cellular network to which the user subscribes. If other frequencies are chosen, they are unavoidably frequencies used in another cellular network, generally belonging to another operator, which poses problems.
- Therefore, the frequencies that can be used in cordless mode must not interfere with the cell in which the mobile terminal is situated while it is operating in cordless mode. One solution would be to use frequency hopping over the various frequencies used in the cellular network so as to average out the transmitted noise, thereby generating less interference. However, that solution is not adopted by the Applicant because it is effective only if the frequency hopping can be performed over a large number of frequencies, e.g. over all 125 GSM frequencies, and not merely over the limited number of frequencies actually allocated to one cellular network. It is therefore necessary to allocate frequencies that are usable in cordless mode only, as a function of the frequency re-use scheme defined for the cellular network, and as a function of the precise location of the private station.
- Such frequency allocation in cordless mode must be transparent for the user. Although it is possible to choose a solution consisting in providing switches on the private station to make it possible to select various frequencies that are usable in cordless mode without interfering with the cellular network, that solution is unattractive to the user.
- Such frequency allocation in cordless mode must also be easy to implement, and it must make maximum use of the means that already exist in the cellular network and in the mobile terminal.

Moreover, it is desirable for the frequency allocation for cordless mode to be easy to implement and to be transparent for the user, in particular when the user is already a subscriber to a cellular network and wishes to acquire cordless mode, and it is also desirable for such frequency allocation to be easy to modify, in particular when the user, who owns a mobile terminal that operates in both modes, moves to a different house. If the user moves to a different house, it is necessary to allocate a new set of one or more frequencies, as a function of the frequency re-use scheme of the network and as a function of the new home address.

The problems are solved and the objects are achieved by means of the present invention which provides a radiotelecommunications system having a mobile terminal equipped with a subscriber identity module and designed to operate in a first mode referred to as "cellular mode" in a cellular network having a plurality of cells, the system further having a private base station independent from said cellular network and connected by wire to a wired telecommunications network, said private base station occupying at least a part of one of the cells of the cellular network, to which cell the cellular network has allocated at least one frequency from among all of the frequencies available in the cellular network using a predetermined frequency re-use scheme, the mobile terminal having selection means enabling it to operate in a second mode referred to as "cordless mode" when it is situated within a predetermined zone in the vicinity of the private base station, in which mode the terminal can set up a call to or receive a call from said wired telecommunications network by communicating by radio with said private base station, radio communication taking place on at least one frequency selected from a predetermined set of one or more frequencies also chosen from among all of the frequencies available in the cellular network except at least those, frequencies which are allocated to said cell, said selection means including storage means for storing said predetermined set of one or more frequencies in a storage zone of the two-part unit formed by the terminal and by the subscriber identity module, wherein, when the terminal operates in cellular mode, said predetermined set of one or more frequencies is previously transmitted by radio from the base station of the cellular network that is closest to the mobile terminal, so that said set of frequencies can be stored in said storage means.

Preferably, the storage zone is situated in the subscriber identity module.

Advantageously, said storage means comprise an elementary file of the subscriber identity module.

Furthermore, said predetermined set of one or more frequencies is advantageously transmitted in the form of a point-to-point short service message, preferably of class 2 in order to prevent the user from reading or writing in the storage means.

BRIEF DESCRIPTION OF THE DRAWINGS

Other characteristics and advantages of the present invention appear clearly from the following description given with reference to the accompanying drawings, in which:

FIG. 1 is a diagram showing various portions of a radiotelecommunications system of the present invention;

FIG. 2 is a block diagram showing various portions of a mobile terminal of the present invention; and

FIG. 3 is a diagram showing various portions of a radiotelecommunications system for which the set of frequencies that can be used in cordless mode is transmitted by the cellular network.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENT

To make the invention easier to understand, like elements are given like references in all three figures.

FIG. 1 shows a portion of a pattern having seven cells C_1 to C_7 for a cellular network, e.g. a digital network of the GSM type. Each cell C_1 to C_7 is suitable for communicating by radio with all of the mobile terminals situated in its coverage zone, by using at least one frequency allocated by the network, which frequency is different from the frequencies used in the adjacent cells. More precisely, calls are set up between a base station **1** assigned to each cell and a mobile terminal **2** that subscribes to the cellular network in question.

In the radiotelecommunications system of the present invention, in addition to being able to operate in the mode defined above and referred to as "cellular mode", the mobile terminal **2** can also operate in a second mode, referred to as "cordless mode". For this cordless second mode, the radiotelecommunications system includes a private base station **3** that is independent from the cellular network. The private base station **3** is further connected by wire **4** to a wired telecommunications network, e.g. of the PSTN type, given overall reference **5** in FIG. **1**. Typically, the private base station **3** is situated at the home of the user, who subscribes both to the cellular network and also to the wired network, or else it may be at the workplace of the user. It is only possible for the mobile terminal to operate in cordless mode when the terminal is situated in a zone close to and surrounding the private base station **3**, which zone is referenced A in FIG. **1** and is defined in the example shown in FIG. **1** by a dashed-line circle. Typically, the zone A may have a diameter of a few tens of meters. During a cordless call, the mobile terminal **2** and the private base station **3** communicate via their respective antennas **20** and **30** by radio on at least one carrier frequency chosen from a predetermined set of one or more frequencies. The call also goes over the wired network **5**.

In FIG. **1**, the private base station **3** is shown located in the cell C_1. As a result, the zone A is also situated, at least in part, in the cell C_1. For the above-mentioned reasons, the predetermined set of one or more frequencies must not include the frequencies allocated to the cell C_1. Preferably, said set of frequencies does not include the frequencies allocated to the cells C_2 to C_7 adjacent to the cell C_1 either. In this way, the frequencies used in cordless mode can only be frequencies used by cells of the network that are far enough away from the private base station **3** to ensure that there is no interference. This is particularly true since the transmission power required at the portable terminal and at the private base station is very low, and typically of the order of a few hundred milliwatts.

With reference to FIG. **2**, a mobile terminal **2** of the present invention mainly comprises, as seen from the outside, a display screen **21**, e.g. of the LCD type, a man-machine interface module **22**, e.g. conventionally comprising keys **23** for dialing purposes, and cursor/navigation means **24** for enabling the user to scroll through menus and sub-menus corresponding to features offered by the terminal. The terminal of the invention further includes selection means making it possible to choose the operating mode for the terminal, the choice being between cellular mode and cordless mode. In FIG. **2**, the selection means are shown constituted by a dedicated key **25** of the man-machine interface. In a variant, the selection means may be accessible via the cursor/navigation means **24**, within a particular menu, or else they may be constituted by a switch on the terminal's case.

In addition, the mobile terminal includes read means (not shown) for reading a module **26** for identifying a subscriber of the cellular network, such a module being conventionally referred to as a "subscriber identity module" (SIM) in a GSM. This module **26** conventionally includes means **27** for storing various information that is not itemized herein. To enable the terminal to operate, the above-mentioned elements are connected to a control module **28** comprising, in particular, a microprocessor. Finally, the terminal has a

processing module **29** for processing the signals, and a radio-frequency module **40** connected to the antenna **20** of the terminal. These modules are well known to the person skilled in the art, and they are not described in detail herein.

According to an essential characteristic of the invention, the predetermined set of one or more frequencies that can be used in cordless mode is pre-recorded in storage means in a storage zone of the two-part unit formed by the mobile terminal and by the subscriber identity module **26**. Preferably, as shown in the figure, the storage zone is situated in the subscriber identity module, e.g. in a file commonly referred to as an "elementary file", and the storage means correspond to the means **27**.

Thus, when the user selects cordless mode via the selection means **25** because the user is at home, the control module **28** reads the information contained in the storage means **27** of the subscriber identity module **26**, and selects the frequency at which the mobile terminal is to operate. If the predetermined set of frequencies comprises a plurality of frequencies, the mobile terminal may advantageously operate by frequency hopping to reduce interference.

In a variant, the storage zone may be a memory zone in the terminal.

It can happen that, when the user wishes to make an outgoing call, and is within the coverage zone A of the private station, the user forgets to select cordless mode. Calls via a cellular network are known to be more expensive than calls going via a wired network. Thus, when the operator of the cellular network is the same as the operator of the wired network, or when there is a partnership agreement between the operators, a particularly advantageous embodiment of the invention is to provide means for setting up the call via the wired network on a priority basis. Such means may, for example, be located at the terminal which listens constantly to both networks. If, on setting up an outgoing call, the terminal becomes aware that it is within the zone A covered by the private base station, it sends its call via the wired network.

Furthermore, for the purposes of receiving an incoming call, the mobile terminal is associated with two telephone numbers, namely a first number whereby it can receive a call via the cellular network, and a second number whereby it can receive a call via the wired network, subject to being within the coverage zone A of the private base station.

Several solutions may be considered for storing the set of one or more frequencies that can be used in cordless mode only.

Firstly, reference is made to the case when a person buys a mobile terminal for the first time and subscribes to a given cellular network. It is then possible for the operator of the cellular network, who knows the home address of the buyer and the corresponding telephone number associated with the wired network, to deliver to the buyer a subscriber identity module that already contains said set of frequencies in a memory in its storage means.

However, it is not possible to use that solution in the more likely case when the user is already a subscriber to the cellular network, and wishes subsequently to obtain the cordless feature by buying a private base station from the operator. In addition, when the user of a mobile terminal that operates both in cellular mode and in cordless mode moves to a different house, it is necessary for the user to return the subscriber identity module to the operator so that said operator can make the necessary modifications.

To overcome the preceding limitation, and according to another important characteristic, the present invention proposes to cause said set of frequencies to be previously transmitted by radio from a base station of the cellular network so that they can be stored in the storage means. More precisely, when the user buys a private base station, the user gives his or her home address. The operator of the cellular network then determines the set of frequencies that can be used in cordless mode as a function of the frequency re-use scheme and as a function of the home address. Provided that the terminal is switched on in cellular mode, the set of frequencies can be transmitted to it via that base station of the cellular network which is closest to the mobile terminal at the time of transmission. Advantageously, the set of frequencies is transmitted by means of a point-to-point short service message. Preferably, this message is of class 2, so as to prevent the user from reading or writing in the storage means.

If the user moves to a different house, it is necessary merely for the user to give the new address to the operator of the cellular network. The operator then modifies the set of frequencies that can be used in cordless mode, and transmits the modified set of frequencies by radio, as before.

If the operator of the cellular network is identical to or in a partnership agreement with the operator of the wired network, storing said set of frequencies or modifying it in the event that the user moves to a different house may even be completely transparent for the user who merely needs to be assigned a line on the wired network. This situation is shown diagrammatically in FIG. **3** which shows that information interchange is possible between the wired network **5** and the cellular network, and more particularly the elements of the cellular network that serve to send a short message to the mobile terminal **2**.

To sum up, the present-invention proposes a radiotelecommunications system in which the same portable telephone set may be used both in a cellular network, and also in a wired network in cordless mode. Furthermore, the system of the invention makes maximum use of the elements that already exist in mobile telephony, and operation of the system can be totally transparent for the user.

Although the description is given with reference to a digital cellular network of the gsm type, it is easy to understand that the invention applies to all types of cellular networks.

What is claimed is:

1. A radiotelecommunications system having a mobile terminal equipped with a subscriber identity module and designed to operate in a first mode referred to as "cellular mode" in a cellular network having a plurality of cells, the radiotelecommunications system comprising:

a private base station independent from said cellular network and connected by wire to a wired telecommunications network, said private base station occupying at least a part of one of the cells of the cellular network, to which cell the cellular network has allocated at least one frequency from among all of the frequencies available in the cellular network using a predetermined frequency re-use scheme;

wherein the mobile terminal comprises:

a selector enabling the mobile terminal to operate in a second mode referred to as "cordless mode" when the mobile terminal is situated within a predetermined zone in the vicinity of the private base station, in which mode the mobile terminal can set up a call to or receive a call from said wired telecommunications network by communicating by radio with said private base station, radio communication taking

place on at least one frequency selected from a predetermined set of one or more frequencies also chosen from among all of the frequencies available in the cellular network except at least those frequencies which are allocated to said cell, said selector comprising:

storage means for storing said predetermined set of one or more frequencies in a storage zone of the two-part unit formed by the mobile terminal and by the subscriber identity module, wherein, when the mobile terminal operates in cellular mode, said predetermined set of one or more frequencies is previously transmitted by radio from a base station of the cellular network that is closest to the mobile terminal, so that said predetermined set of one or more frequencies can be stored in said storage means.

2. A radiotelecommunications system according to claim 1, wherein the storage zone is situated in the subscriber identity module.

3. A radiotelecommunications system according to claim 2, wherein said storage means comprise an elementary file of the subscriber identity module.

4. A radiotelecommunications system according to claim 1, wherein said predetermined set of one or more frequencies is transmitted in the form of a point-to-point short service message.

5. A radiotelecommunications system according to claim 4, wherein said point-to-point short service message is of class 2.

6. A radiotelecommunications system according to claim 1, wherein said selector comprises:

a switch accessible to the user of the mobile terminal to enable the user to select the operating mode of the mobile terminal between "cellular mode" and "cordless mode".

7. A radiotelecommunications system according to claim 1, wherein the mobile terminal is associated with two telephone numbers whereby the mobile terminal can receive an incoming call, namely a first telephone number whereby the incoming call comes from the cellular network, and a second telephone number whereby the incoming call comes from the wired telecommunications network.

8. A radiotelecommunications system according to claim 1, wherein, whenever the mobile terminal is setting up an outgoing call via the cellular network while the mobile terminal is situated within said zone in the vicinity of the private base station, the cellular network comprises:

a wired network priority controller for setting up the call via the wired telecommunications network on a priority basis.

9. A radiotelecommunications system according to claim 1, wherein the frequencies allocated to the cells adjacent to said cell are also excluded from said predetermined set of one or more frequencies.

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United States Patent [19]

Gillig et al.

[11] Patent Number: 6,141,560

[45] Date of Patent: *Oct. 31, 2000

[54] **COMMUNICATION DEVICE PROVIDING DUAL MODE OPERATION**

[75] Inventors: **Steven F. Gillig**, Roselle; **Glen E. Pederson**, St. Charles, both of Ill.

[73] Assignee: **Motorola, Inc.**, Schaumburg, Ill.

[*] Notice: This patent is subject to a terminal disclaimer.

[21] Appl. No.: **08/654,502**

[22] Filed: **May 28, 1996**

Related U.S. Application Data

[62] Division of application No. 08/523,982, Sep. 6, 1995, abandoned, which is a division of application No. 08/275,883, Jul. 15, 1994, Pat. No. 5,463,674, which is a continuation of application No. 08/134,431, Oct. 12, 1993, abandoned, which is a division of application No. 08/103,169, Aug. 6, 1993, which is a continuation of application No. 07/826,322, Jan. 2, 1992, abandoned, which is a division of application No. 07/660,180, Feb. 25, 1991, Pat. No. 5,127,042, which is a continuation of application No. 07/516,375, Apr. 30, 1990, abandoned, which is a division of application No. 07/249,041, Sep. 23, 1988, Pat. No. 4,989,230.

[51] **Int. Cl.**[7] **H04B 1/38**; H04M 1/00

[52] **U.S. Cl.** **455/550**

[58] **Field of Search** 379/59, 57, 433, 379/61, 143; 340/825-49; 370/71; 455/77, 550

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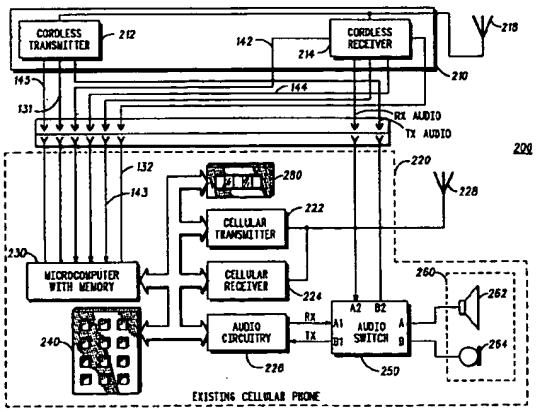
Primary Examiner—William Cumming

Attorney, Agent, or Firm—John G. Rauch; Brian Mancini

[57] **ABSTRACT**

A cellular cordless telephone (**10**) operates with both a cordless base station (**180**) and a cellular base station (**190**) and cellular control terminal (**196**). In one embodiment (FIG. **2**), a cellular cordless telephone (**100**) includes a cellular transceiver (**120**), antenna (**128**), keyboard (**140**), a display (**180**), handset (**160**), and microcomputer (**130**) together with a cordless transceiver (**110**) and antenna (**118**), all of which may be in a single housing. In another embodiment (FIG. **3**), a cellular cordless telephone (**200**) includes a cellular telephone (**220**) and a cordless telephone transceiver (**210**) which may be a plugable module. Whenever cellular cordless telephone (**10**) is within range of cordless base station (**180**), telephone calls may be made over the cordless radio channel or transferred from the cellular radio channels to the cordless radio channel. If the cellular cordless telephone (**10**) thereafter moves out of range of the cordless base station (**180**), telephone calls may be made over the cellular radio channels or transferred from the cordless radio channel to one of the cellular telephone channels.

28 Claims, 7 Drawing Sheets



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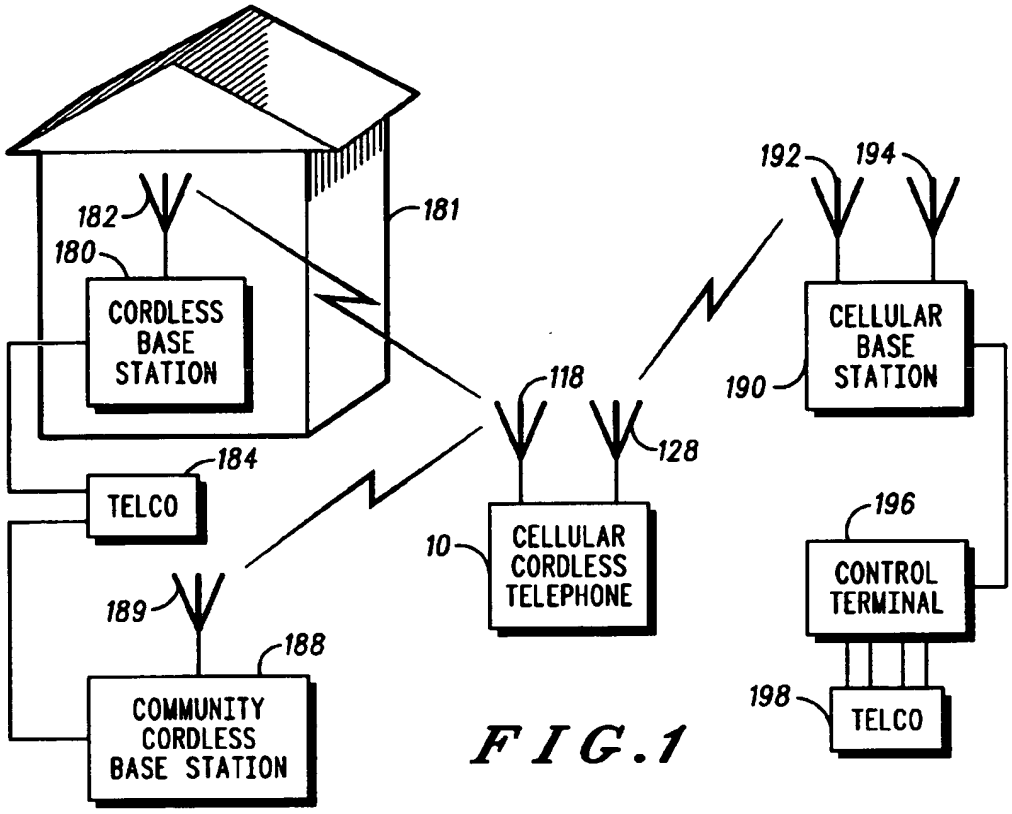

182
180
181
CORDLESS BASE STATION
184
TELCO
189
188
COMMUNITY CORDLESS BASE STATION
118
128
10
CELLULAR CORDLESS TELEPHONE
192
194
CELLULAR BASE STATION
190
196
CONTROL TERMINAL
198
TELCO

FIG. 1

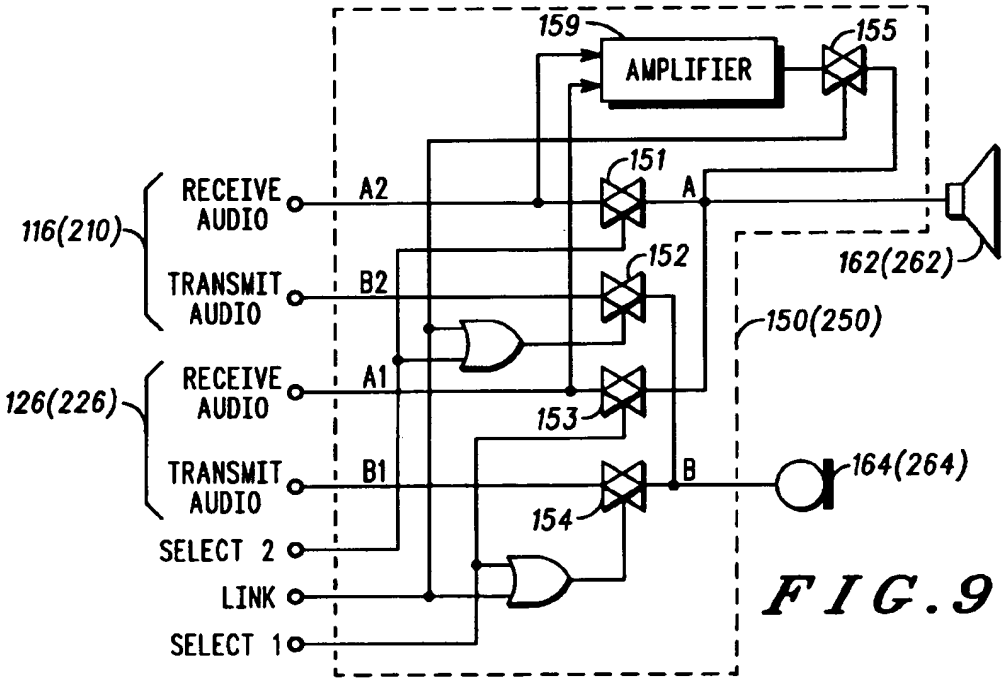

159
AMPLIFIER
155
151
152
153
154
RECEIVE AUDIO
TRANSMIT AUDIO
RECEIVE AUDIO
TRANSMIT AUDIO
SELECT 2
LINK
SELECT 1
A2
B2
A1
B1
A
B
116(210)
126(226)
150(250)
162(262)
164(264)

FIG. 9

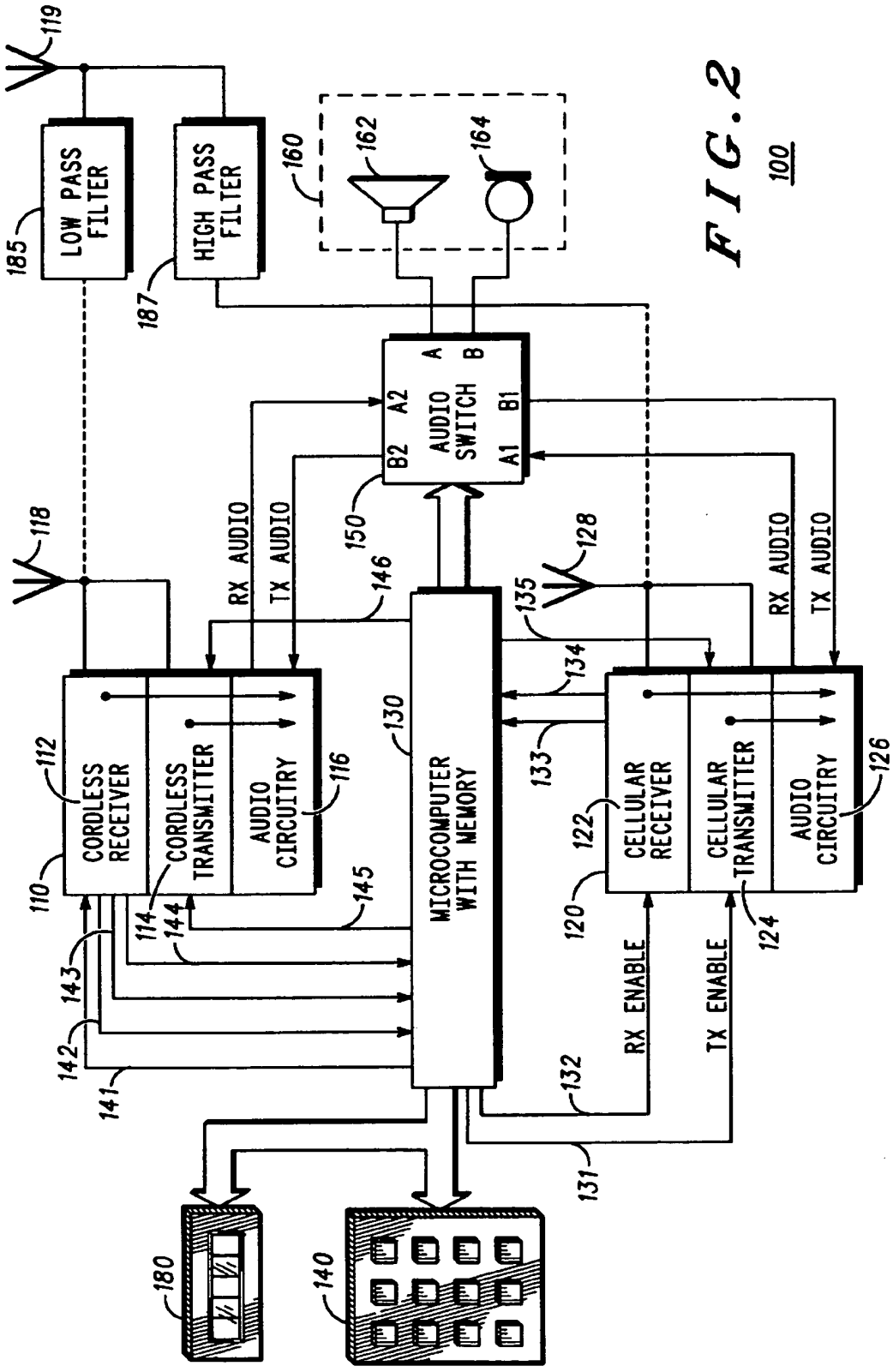
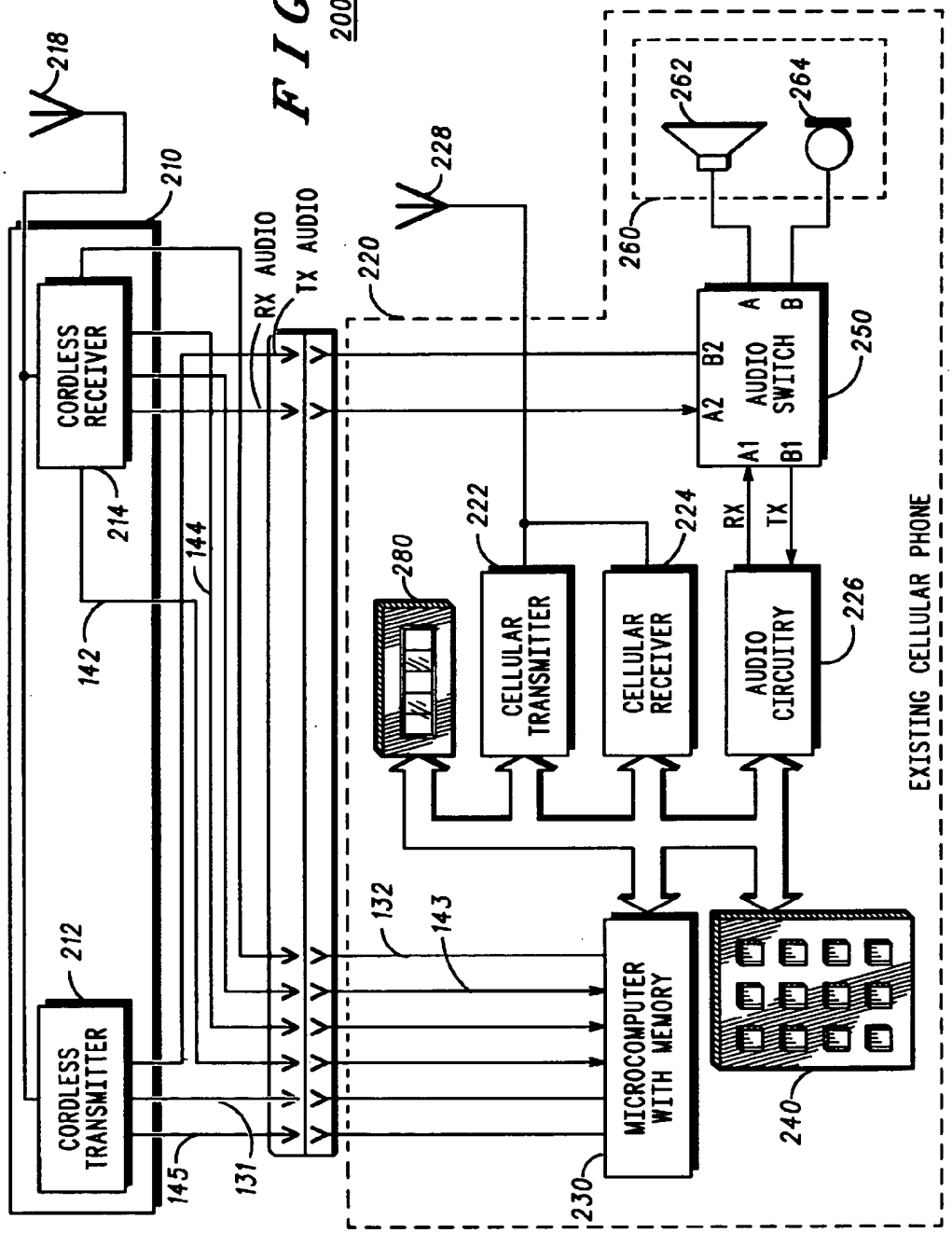

119
LOW PASS FILTER
185
HIGH PASS FILTER
187
160
162
164
A
B
A2
AUDIO SWITCH
B1
B2
A1
150
118
RX AUDIO
TX AUDIO
146
128
135
134
130
133
112
CORDLESS RECEIVER
CORDLESS TRANSMITTER
AUDIO CIRCUITRY
116
MICROCOMPUTER WITH MEMORY
122
CELLULAR RECEIVER
CELLULAR TRANSMITTER
AUDIO CIRCUITRY
126
110
114
144
145
120
124
143
142
141
RX ENABLE
TX ENABLE
132
131
180
140

FIG. 2

100

FIG. 3


200
218
210
228
220
260
262
264
RX AUDIO
TX AUDIO
CORDLESS RECEIVER
214
144
142
212
CORDLESS TRANSMITTER
145
131
A
B
A2 B2
AUDIO SWITCH
A1 B1
250
RX
TX
222
224
280
CELLULAR TRANSMITTER
CELLULAR RECEIVER
AUDIO CIRCUITRY
226
132
143
MICROCOMPUTER WITH MEMORY
230
240
EXISTING CELLULAR PHONE

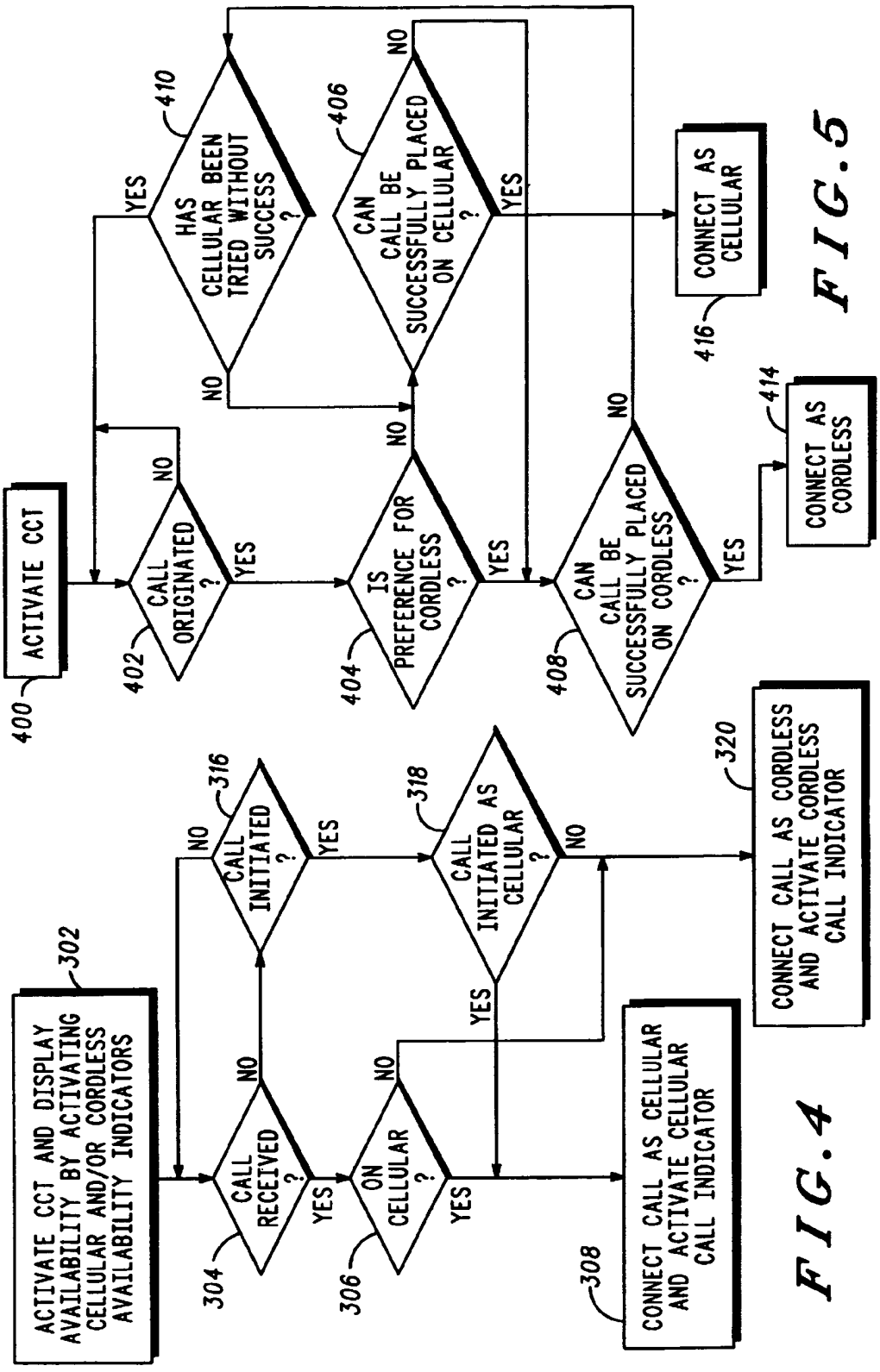
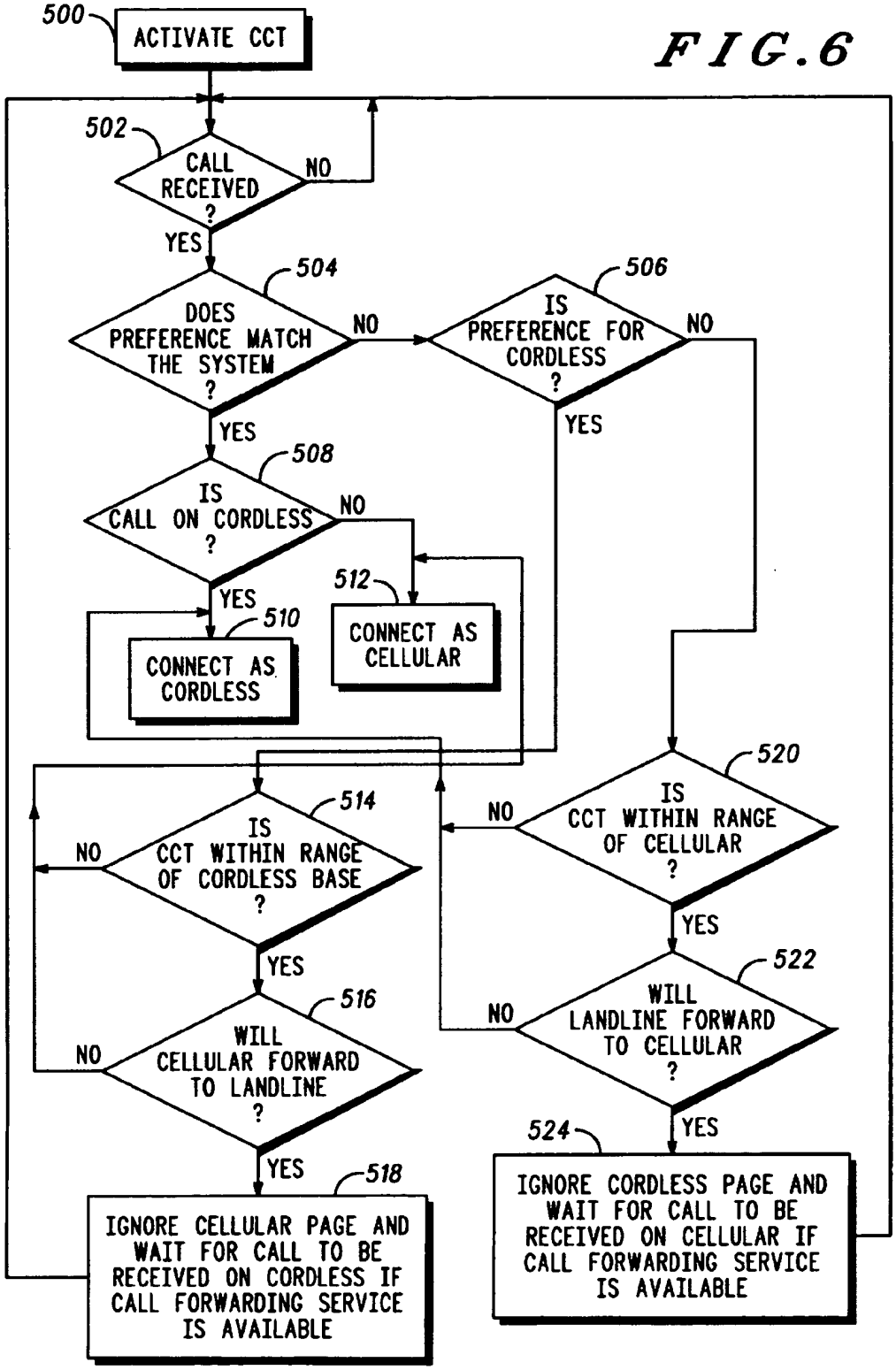

ACTIVATE CCT AND DISPLAY AVAILABILITY BY ACTIVATING CELLULAR AND/OR CORDLESS AVAILABILITY INDICATORS
302
CALL RECEIVED ?
304
ON CELLULAR ?
306
CONNECT CALL AS CELLULAR AND ACTIVATE CELLULAR CALL INDICATOR
308
CALL INITIATED ?
316
CALL INITIATED AS CELLULAR ?
318
CONNECT CALL AS CORDLESS AND ACTIVATE CORDLESS CALL INDICATOR
320
YES
NO

FIG. 4

ACTIVATE CCT
400
CALL ORIGINATED ?
402
IS PREFERENCE FOR CORDLESS ?
404
CAN CALL BE SUCCESSFULLY PLACED ON CORDLESS ?
408
CONNECT AS CORDLESS
414
CAN CALL BE SUCCESSFULLY PLACED ON CELLULAR ?
406
HAS CELLULAR BEEN TRIED WITHOUT SUCCESS ?
410
CONNECT AS CELLULAR
416
YES
NO

FIG. 5

FIG. 6


500
ACTIVATE CCT
502
CALL RECEIVED ?
NO
YES
504
DOES PREFERENCE MATCH THE SYSTEM ?
NO
506
IS PREFERENCE FOR CORDLESS ?
NO
YES
YES
508
IS CALL ON CORDLESS ?
NO
YES
510
CONNECT AS CORDLESS
512
CONNECT AS CELLULAR
514
IS CCT WITHIN RANGE OF CORDLESS BASE ?
NO
YES
516
WILL CELLULAR FORWARD TO LANDLINE ?
NO
YES
518
IGNORE CELLULAR PAGE AND WAIT FOR CALL TO BE RECEIVED ON CORDLESS IF CALL FORWARDING SERVICE IS AVAILABLE
520
IS CCT WITHIN RANGE OF CELLULAR ?
NO
YES
522
WILL LANDLINE FORWARD TO CELLULAR ?
NO
YES
524
IGNORE CORDLESS PAGE AND WAIT FOR CALL TO BE RECEIVED ON CELLULAR IF CALL FORWARDING SERVICE IS AVAILABLE

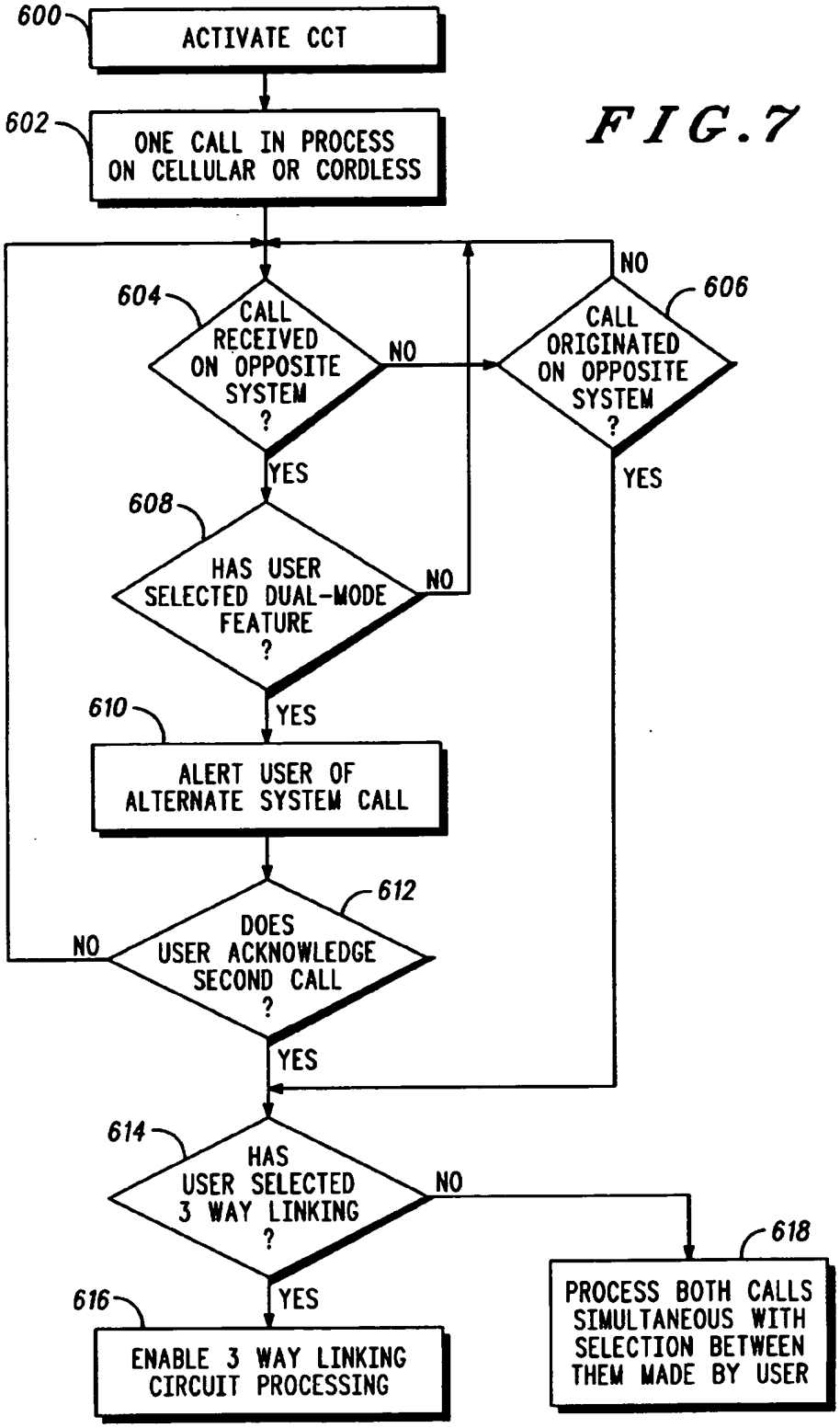

600
ACTIVATE CCT
602
ONE CALL IN PROCESS ON CELLULAR OR CORDLESS
604
CALL RECEIVED ON OPPOSITE SYSTEM ?
NO
606
CALL ORIGINATED ON OPPOSITE SYSTEM ?
NO
YES
YES
608
HAS USER SELECTED DUAL-MODE FEATURE ?
NO
YES
610
ALERT USER OF ALTERNATE SYSTEM CALL
612
DOES USER ACKNOWLEDGE SECOND CALL ?
NO
YES
614
HAS USER SELECTED 3 WAY LINKING ?
NO
YES
616
ENABLE 3 WAY LINKING CIRCUIT PROCESSING
618
PROCESS BOTH CALLS SIMULTANEOUS WITH SELECTION BETWEEN THEM MADE BY USER

FIG. 7

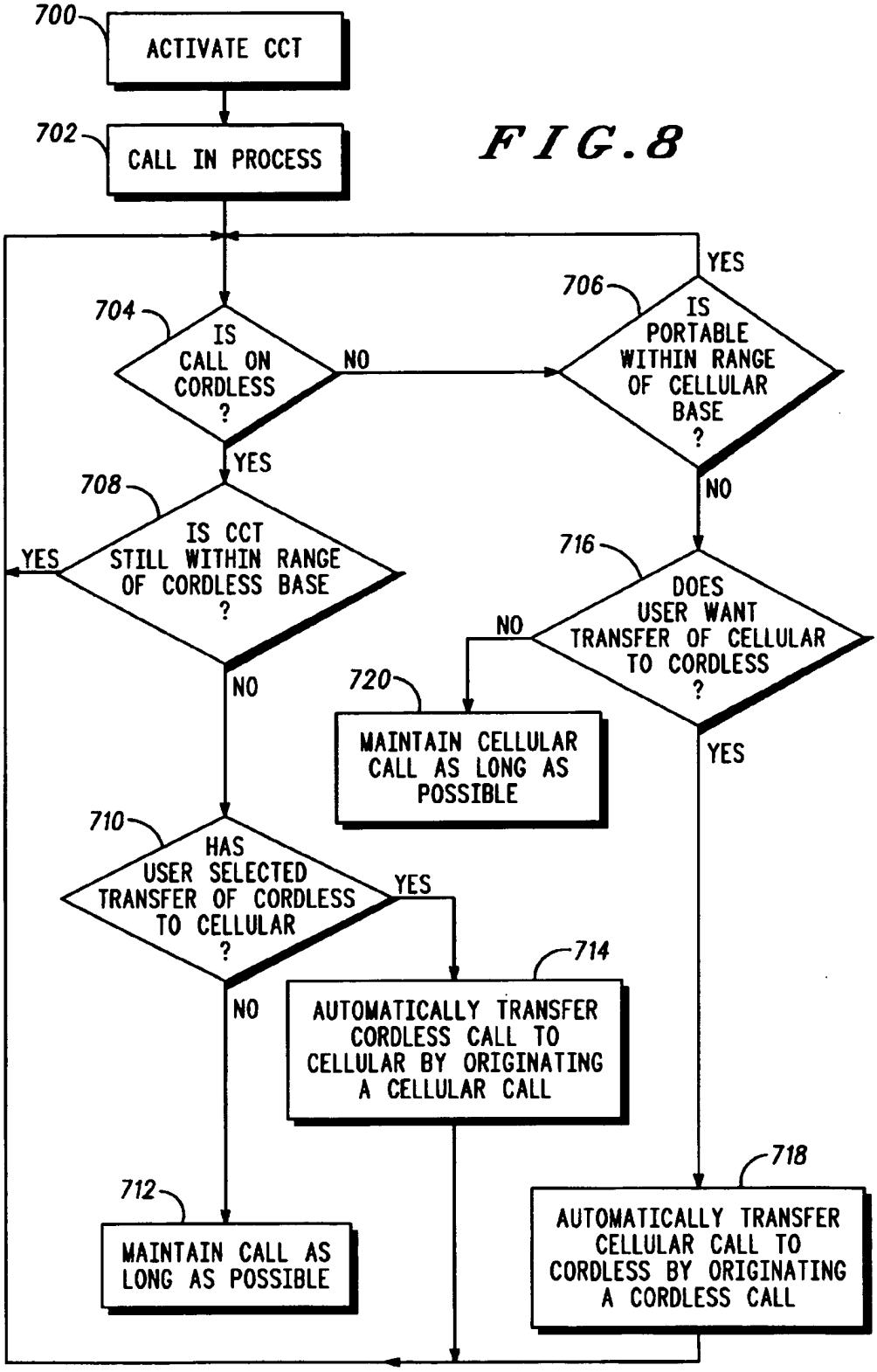

700
ACTIVATE CCT
702
CALL IN PROCESS
704
IS CALL ON CORDLESS ?
NO
YES
706
IS PORTABLE WITHIN RANGE OF CELLULAR BASE ?
YES
NO
708
IS CCT STILL WITHIN RANGE OF CORDLESS BASE ?
YES
NO
716
DOES USER WANT TRANSFER OF CELLULAR TO CORDLESS ?
NO
YES
720
MAINTAIN CELLULAR CALL AS LONG AS POSSIBLE
710
HAS USER SELECTED TRANSFER OF CORDLESS TO CELLULAR ?
YES
NO
714
AUTOMATICALLY TRANSFER CORDLESS CALL TO CELLULAR BY ORIGINATING A CELLULAR CALL
712
MAINTAIN CALL AS LONG AS POSSIBLE
718
AUTOMATICALLY TRANSFER CELLULAR CALL TO CORDLESS BY ORIGINATING A CORDLESS CALL

FIG. 8

COMMUNICATION DEVICE PROVIDING DUAL MODE OPERATION

This is a division of application Ser. No. 08/523,982 filed Sep. 6, 1995, now abandoned which is a division of application Ser. No. 08/275,883 filed Jul. 15, 1994, now U.S. Pat. No. 5,463,674 which is a continuation of application Ser. No. 08/134,431 filed Oct. 12, 1993 and now abandoned, which is a division of application Ser. No. 08/103,169 filed Aug. 6, 1993, which is a continuation of application Ser. No. 07/826,322, filed Jan. 2, 1992 and now abandoned, which is a division of application Ser. No. 07/660,180 filed Feb. 25, 1991 and now U.S. Pat. No. 5,127,042, which is a continuation of Ser. No. 07/516,375 filed Apr. 30, 1990 and now abandoned, which in turn is a division of application Ser. No. 07/249,041 filed on Sep. 23, 1988 and now U.S. Pat. No. 4,989,230.

BACKGROUND OF THE INVENTION

The present invention is generally related to cellular telephones and more particularly to an improved cellular cordless telephone for providing both cellular and cordless telephone services.

In the prior art, cordless telephones typically are used in the home to allow the user to place and receive telephone calls at any point throughout the house. Such cordless telephones are connected to the user's telephone landline. However, due to their limited range, such cordless telephones are not suitable for use in vehicles. Vehicular communications are typically achieved by means of radio telephone systems, the most prevalent being cellular telephone systems. A cellular telephone allows the user to place and receive telephone calls at any point throughout a large metropolitan area. However, the cost of a cellular telephone call is as much as seven times the cost of a cordless telephone call, since cordless telephone calls are made by way of the user's telephone landline and cost the same as landline telephone calls, while cellular telephone calls are made by way of expensive cellular base stations and cellular switching equipment and cost much more than landline telephone calls.

OBJECTS OF THE INVENTION

Accordingly, it is an object of the present invention to provide an improved cellular cordless telephone that may place both cellular telephone calls and cordless telephone calls.

It is another object of the present invention to provide an improved cellular cordless telephone that automatically operates as a cordless telephone whenever it is in range of its corresponding cordless base station.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. **1** is a block diagram of a cellular cordless telephone system embodying the present invention.

FIG. **2** is a block diagram of a cellular cordless telephone embodying the present invention.

FIG. **3** is a block diagram of another embodiment of a cellular cordless telephone according to the present invention.

FIG. **4** is a flow chart for the process used by the cellular cordless telephones in FIGS. **2** and **3** for placing and receiving cellular and cordless telephone calls.

FIG. **5** is a flow chart for the process used by the cellular cordless telephones in FIGS. **2** and **3** for originating a telephone call as a cellular telephone call or a cordless telephone call according to user selectable preference.

FIG. **6** is a flow chart for the process used by the cellular cordless telephones in FIGS. **2** and **3** for receiving a telephone call as a cellular telephone call or a cordless telephone call according to user selectable preference.

FIG. **7** is a flow chart for the process used by the cellular cordless telephones in FIGS. **2** and **3** for simultaneously processing both a cellular telephone call and a cordless telephone call and three-way linking both calls.

FIG. **8** is a flow chart for the process used by the cellular cordless telephones in FIGS. **2** and **3** for automatically transfering between a cellular telephone call and a cordless telephone call.

FIG. **9** is a block diagram of audio switch **150** in the cellular cordless telephone in FIG. **2**.

DESCRIPTION OF THE PREFERRED EMBODIMENT

In FIG. **1**, there is illustrated a block diagram of a cellular cordless telephone system embodying the present invention. The system includes a telephone company phone system (TELCO) **184**, connected by telephone landlines to a cordless base station **180** having a landline telephone number located in a home or office **181** and to a community cordless base station **188** having a landline telephone number in another office, building, or other geographical location. Cordless base stations **180** and **188** communicate with a communication device, the cellular cordless telephone (CCT) **10**, through antennas **182** and **189**. Antennas **182** and **189** may be implemented as telescoping whip antennas. Cordless base stations **180** and **188** may be any conventional cordless base station, such as, for example, the base station shown and described in Panasonic operating instructions, entitled "Cordlessphone Model No. KX-T3000 EASA-PHONE", published by and available from the Panasonic Company, One Panasonic Way, Secaucus, N.J., 07094. Additional community cordless base stations **188** may be located throughout a metropolitan area for providing shared cellular telephone service to CCTs **10**. In this case, cordless base station **188** may include additional equipment for billing calls to the telephone number of CCT **10**.

Also connected through telephone landlines to the same or a different telephone company phone system (TELCO) **198** is the cellular control terminal **196** (see U.S. Pat. No. 4,268,722) with its associated cellular base station(s) **190** (see U.S. Pat. No. 4,485,486 incorporated herein by reference). Cellular base station **190** incorporates both a receive antenna **192** and a transmit antenna **194** (see U.S. Pat. No. 4,369,520 incorporated herein by reference) for communicating with CCTs **10**.

CCT **10** is a communication device which may be a mobile unit installed in a vehicle, a transportable unit which is a mobile unit and battery installed in a carrying case, or a hand-held portable unit. CCT **10** includes an antenna **118** for the cordless radio channels and an antenna **128** for the cellular radio channels as illustrated by the embodiment of CCT **200** in FIG. **3**, or may include a single antenna, is illustrated by the embodiment of CCT **100** in FIG. **2**. In the U.S.A., the cordless radio channels are in the frequency band from 46–49 mHz and the cellular radio channels are in the frequency band from 824–894 mHz.

In FIG. **2**, there is illustrated a detailed block diagram of a first embodiment of a CCT **100** according to the present invention. CCT **100** includes a cordless telephone transceiver **110**, antenna **118**, cellular telephone transceiver **120**,

antenna 128, microcomputer 130, keypad 140, display 180, audio switch 150, and handset 160 including speaker 162 and microphone 164. Alternatively, as shown by dashed-lines in FIG. 2, cordless telephone transceiver 110 and cellular telephone transceiver 120 may be coupled to a single antenna 119 in place of antennas 118 and 128 by way of low-pass filter 185 and high-pass filter 187, respectively. Cordless telephone transceiver 110 may be any conventional cordless telephone transceiver, such as, for example the transceiver shown and described in the aforementioned Panasonic operating instructions, entitled "Cordlessphone Model No. KX-T3000 EASA-PHONE". Cellular telephone transceiver 120, microcomputer 130, keypad 140, and handset 160 likewise may be any commercially available cellular transceiver, such as, for example, the transceiver shown and described in Motorola instruction manual number 68P81049E55, entitled "DYNATAC Cellular Mobile Telephone", published by and available from Motorola C & E Parts, 1313 East Algonquin Road, Schaumburg, Ill. 60196.

Referring to FIG. 9, audio switch 150 may be implemented with two-to-one multiplexing analog switches 151–155 which select between audio signals of audio circuitry 116 in cordless transceiver 110 and audio circuitry 126 in cellular transceiver 120 under control of select signals SELECT1, SELECT2 and LINK from microcomputer 130. Select signal SELECT2 enables switches 151 and 152 when it has a binary one state, select signal SELECT1 enables switches 153 and 154 when it has a binary one state, and select signal LINK enables switches 152, 154 and 155 when it has a binary one state. Depending on which is enabled, analog switches 151 and 153 couple speaker 162 to receive audio from audio circuitry 116 and audio circuitry 126, respectively. Similarly, depending on which is enabled, analog switches 152 and 154 couple microphone 164 to transmit audio of audio circuitry 116 and audio circuitry 126, respectively. If three-way linking is selected, analog switches 152 and 154 couple microphone 164 to transmit audio of both audio circuitry 116 and audio circuitry 126, and analog switch 155 couples speaker 162 to receive audio of both audio circuitry 116 and audio circuitry 126 by way of summing amplifier 159.

Referring to CCT 100 in FIG. 2, microcomputer 130 is programmed in accordance with FIGS. 4–8 for operating as a cellular telephone, a cordless telephone, or a cellular cordless telephone. That is, according to the present invention, CCT 100 may simultaneously operate as a cellular telephone and a cordless telephone. When operating as a cellular telephone, control signals 131 TX ENABLE and 132 RX ENABLE of microcomputer 130 enable cellular transmitter 124 and cellular receiver 122, respectively. In addition to control signals 131 and 132 to cellular transceiver 120, microcomputer 130 also monitors control signals 133 RSSI, 134 RX DATA and 135 TX DATA for detecting signal strength, for detecting receive data and for sending transmit data, respectively, used in operation of cellular transceiver 120. When operating as a cordless telephone, control signals 141 and 146 of microcomputer 130 enable cordless receiver 112 and cordless transmitter 114, respectively. In addition to control signals 141 and 146 to cordless transceiver 110, microcomputer 130 also monitors control signals 142 SIGNAL QUALITY, 143 RING, 144 RX SECURITY CODE and 145 TX SECURITY CODE for detecting signal strength, ringing, and the receive security code, and for sending the transmit security code and dialed digits, respectively, used in operation of cordless transceiver 110. Dialed digits may also be encoded by keypad 140 as conventional multi-frequency tones which are coupled to transmit audio of cordless transceiver 110 by audio switch 150 during cordless operation.

Referring next to FIG. 3, there is illustrated a block diagram of another embodiment of a communication device, cellular cordless telephone (CCT) 200, according to the present invention. CCT 200 includes a cordless telephone transceiver 210 in a second or separate housing with antenna 218 and connector 270, and a cellular telephone 220 in a first or separate housing with antenna 228 and connector 272. Cordless telephone transceiver 210 may be a plug-in accessory which couples via connectors 270 and 272 to cellular telephone 220. When cordless telephone transceiver 210 is plugged into microcomputer 230 of cellular telephone 220, it operates in accordance with FIGS. 4–8. Cellular telephone 220 includes cellular transmitter 222, cellular receiver 224, microcomputer 230, keypad 240, display 280, audio circuitry 226, audio switch 250 and handset 260 including speaker 262 and microphone 264. Cordless telephone transceiver 210 is a second communication circuit contained in a second housing and configured for two-way speech communication according to a second communication protocol, such as a cordless telephone communication protocol at 46–49 MHz and may be any conventional cordless telephone transceiver, such as, for example the transceiver shown and described in the aforementioned Panasonic operating instructions, entitled "Cordlessphone Model No. KX-T3000 EASA-PHONE". Cellular telephone 220 likewise is a first communication circuit contained in a first housing and configured for two-way speech communication according to a second communication protocol, such as a cellular communication protocol at 824–894 MHz and may be any commercially available cellular transceiver, such as, for example, the transceiver shown and described in the aforementioned Motorola instruction manual number 68P81049E55, entitled "DYNATAC Cellular Mobile Telephone".

Microcomputer 230 of cellular telephone 220 is coupled to the cordless telephone transceiver 210 via the same control signals used in FIG. 2. These control signals are TX/RX enable signals, signal quality signal, ring signal and TX/RX security code signals.

Audio circuitry 226 of cellular telephone 220 is coupled to audio switch 250 which can be implemented with two-to-one multiplexing analog switches (see FIG. 9) which select between audio signals from audio circuitry 226 and cordless telephone transceiver 210.

Referring now to FIG. 4, there is illustrated a flow chart for the process used by the CCTs 100 and 200 in FIGS. 2 and 3, respectively, for placing and receiving cellular and cordless telephone calls. Entering at block 302, the user activates the CCT. The microcomputer 130 and 230 monitors both the cellular and cordless systems for availability thereof and for incoming and outgoing calls. If the cellular system and/or cordless system are available, a corresponding availability indicator is enabled in display 180 and 280. In cellular systems, the microcomputer scans pre-selected signalling channels to determine if cellular service is available. Next, at decision block 304, a check is made to determine if a call has been received. If not, NO branch is taken to decision block 316 to determine if a call has been initiated by the user of the CCT. If not, NO branch is taken back to block 304 to continue monitoring both the cellular and cordless systems for telephone calls.

Returning to decision block 304, if an incoming call has been received, YES branch is taken to decision block 306 where a check is made to determine if the incoming call is

a cellular call. If so, YES branch is taken to block **308** where a cellular call indicator is activated or entered in display **180** and **280**, and the incoming call is connected as a cellular call (e.g., in FIG. **2**, cellular transceiver **120** is enabled by microcomputer **130**). If the incoming call is not a cellular call, NO branch is taken from block **306** to block **320** where a cordless call indicator is activated or entered in display **180** and **280**, and the incoming call is connected as a cordless call (e.g., in FIG. **2**, cordless transceiver **110** is enabled by microcomputer **130**).

Returning to decision block **316**, if a call has been initiated by the user of the CCT, YES branch is taken to decision block **318** where a check is made to determine if the initiated call is a cellular call. If so, YES branch is taken to block **308** where the initiated call is connected as a cellular call. If the initiated call is not a cellular call, NO branch is taken from decision block **318** to block **320** where the initiated call is connected as a cordless call.

Referring now to FIG. **5**, there is illustrated a flow chart for the process used by the CCTs **100** and **200** in FIGS. **2** and **3**, respectively, for originating a telephone call as a cellular telephone call or a cordless telephone call according to user selectable preference.

Entering at block **400**, the user activates the CCT. Next, at block **402**, a check is made to determine if a call has been originated by the CCT. If not, NO branch is taken to wait for a call to be originated. If a call has been originated, YES branch is taken from decision block **402** to decision block **404**, where a check is made to determine if the user's preference is for cordless phone operation. If not, No branch is taken to block **406** to determine if a call can be placed on the cellular system. If so, YES branch is taken to block **416** where the call origination is connected as a cellular call. If not, NO branch is taken to decision block **408** to determine if a call can be successfully placed on the cordless system. Referring back to decision block **404**, if preference is for cordless, YES branch is also taken to decision block **408**. If a cordless call can be successfully placed, YES branch is taken from decision block **408** to decision block **414** where the call is connected as a cordless call. If not, NO branch is taken to decision block **410** to determine if a call had been tried unsuccessfully on the cellular system. If so, YES branch is taken to block **402** to wait for a call origination. If not, NO branch is taken to decision block **406** to determine if the call can be placed on the cellular system.

Referring now to FIG. **6**, there is illustrated a flow chart for the process used by the CCTs **100** and **200** in FIGS. **2** and **3**, respectively, for receiving a telephone call as a cellular telephone call or a cordless telephone call according to user selectable preference.

Entering at block **500**, the user activates the CCT. Next, at decision block **502**, a check is made to determine if a call is being received by the CCT. If not, NO branch is taken back to decision block **502**. If a call has been received, YES branch is taken from decision block **502** to decision block **504** to determine if the user's system preference matches the system of the incoming call. If so, YES branch is taken to decision block **508** to determine if the call is on the cordless system. If so, the YES branch is taken to block **510** where the incoming call is connected as a cordless call. If not, the NO branch is taken to block **512** where the incoming call is connected as a cellular call.

Returning to decision block **504**, if the user's system preference does not match the system of the incoming call, NO branch is taken to decision block **506** to determine if the preference is for the cordless system. If so, the YES branch is taken to decision block **514** to determine if the CCT is within range of the cordless base station (e.g., by sending the transmit security code and waiting for the receive security code from the cordless base station). If not, the NO branch is taken to block **512** where the incoming call is connected as a cellular call. If the cellular cordless telephone is within range of the cordless base station, YES branch is taken from decision block **514** to decision block **516** to determine if the cellular system will forward the unanswered incoming call to the landline of the cordless base station when the cellular phone cannot be reached. This type of service is generally referred to as "call forwarding" (call forwarding is a conventional process which is described in a person's telephone directory) and can be determined by polling stored information in the memory associated with the CCT microcomputer. If not, NO branch is taken to block **512** where the incoming call is connected as a cellular call. If the cellular system will forward the unanswered incoming call, YES branch is taken from decision block **516** to block **518** where the cellular page from the cellular base station is ignored and thereafter to decision block **502** to wait for the incoming call to be received as a cordless call.

Returning to decision block **506**, if the preference is for a cellular call, NO branch is taken to decision block **520** to determine if the CCT is within range of the cellular base stations (does it have cellular service). This is typically determined by scanning and selecting the strongest signalling channel from the surrounding cellular base stations. If not, NO branch is taken to block **510**, where the incoming call is connected as a cordless call. If the CCT is within range of the cellular base stations, YES branch is taken from decision block **520** to decision block **522** to determine if the landline system will forward the unanswered incoming call to the cellular system. This type of service is generally referred to as "call forwarding" (call forwarding is a conventional process which is described in a person's telephone directory) and can be determined by polling stored information in the memory associated with the CCT microcomputer. If not, NO branch is taken to block **510** where the incoming call is connected as a cordless call. If the landline telephone system will forward the unanswered incoming call, YES branch is taken from decision block **522** to block **524** where the cordless page from the cordless base station is ignored and thereafter back to decision block **502** to wait for the incoming call to be received as a cellular call.

Referring now to FIG. **7**, there is illustrated a flow chart for the process used by the CCTs **100** and **200** in FIGS. **2** and **3**, respectively, for simultaneously processing both a cellular telephone call and a cordless telephone call and, if desired, three-way linking both calls.

Entering at block **600**, the user activates the CCT. Next, at block **602**, one call is assumed to be in process on either the cellular system or cordless system. Proceeding from block **602** to decision block **604**, a check is made to determine if a call has been received on the opposite system from the call in process. If so, YES branch is taken to decision block **608** to determine if the user has selected the dual-mode feature (e.g., by entering a predetermined code from the keypad). If not, NO branch is taken back to decision block **604** and the current call remains in process. If the user has selected the dual-mode feature, YES branch is taken from decision block **608** to block **610** which alerts the user of an incoming call on the alternate system. This type of service is generally referred to as "call waiting". Next, at decision block **612**, a check is made to see if the user acknowledges the second call. If not, NO branch is taken back to decision block **604** and the current call remains in

process. If the user acknowledges the second call (e.g., by flashing the hookswitch), YES branch is taken from decision block **612** to decision block **614** to determine if the user has selected three-way linking (e.g., by entering a predetermined code from the keypad). If so, YES branch is taken to block **616** which enables three-way linking of the user and the two calls, each of which is on a different system. Three-way linking may be accomplished by switchably coupling the combined receive audio signals from summing amplifier **159** via analog gate **155** to the speaker, and enabling both transmit audio switches **152** and **154** in FIG. **9**. If the user has not selected three-way linking, NO branch is taken from decision block **614** to block **618** to process both calls simultaneously, one over each system, but selection between them is made by the user so that only one party is in conversation with the user at a time. Selection between the calls may be made pressing a pre-selected key or set of keys on the keypad.

Returning to decision block **604**, if a call has not been received on the opposite system, NO branch is taken to decision block **606** to determine if a call has been originated on the opposite system. If not, NO branch is taken back to decision block **604**. If a call has been originated on the opposite system, YES branch is taken from decision block **606** to decision block **614** to determine if the user wants three-way linking, as described hereinabove.

Referring now to FIG. **8**, there is illustrated a flow chart for the process used by the CCTs **100** and **200** in FIGS. **2** and **3**, respectively, for automatically transfering between a cellular telephone call and a cordless telephone call.

Entering at block **700**, the user activates the CCT. Next at block **702**, a call is assumed to be in process on one of the two systems. Proceeding from block **702** to decision block **704**, a check is made to determine if the call in process is on the cordless system. If so, YES branch is taken to decision block **708** to determine if the CCT is still within range of the cordless base stations (e.g., signal quality is good). If so, YES branch is taken back to decision block **704**. If the cellular cordless telephone is out of range of the cordless base stations, NO branch is taken from decision block **708** to decision block **710** to determine if the user has selected transfer of the cordless call to the cellular system (e.g., by entering a predetermined code from the keypad). If so, YES branch is taken to block **714** where an attempt is made to transfer the cordless call to the cellular system. Assuming the called party has "call waiting", the transfer is attempted by originating another call on the cellular system and waiting for the called party to answer. Thereafter, the path returns to decision block **704**. If the user has not selected call transfer, NO branch is taken from decision block **710** to block **712** where the cordless call is maintained as long as possible.

Returning to decision block **704**, if the call is not on the cordless system, NO branch is taken to decision block **706** to determine if the CCT is still within range of the cellular base stations (e.g., signal quality is good). If so, YES branch is taken back to decision block **704**. If the CCT is out of range of the cellular base stations, NO branch is taken from decision block **706** to decision block **716** to determine if the user has selected transfer of the cellular call to the cordless system (e.g., by entering a predetermined code from the keypad). If not, NO branch is taken to block **720** where the cellular call is maintained as long as possible. If the user has selected call transfer, YES branch is taken from decision block **716** to block **718** where an attempt is made to transfer the cellular call to the cordless system. Assuming the called party has "call waiting", the transfer is attempted by originating another call on the cordless system and waiting for the called party to answer. Thereafter, the path returns to decision block **704**.

In summary, a unique cellular cordless telephone has been described that may be advantageously utilized for making both cellular telephone calls and cordless telephone calls. Whenever the cellular cordless telephone is within range of the cordless base station, telephone calls are preferably originated on the cordless system, or if currently in process, are transferred to the cordless telephone system.

We claim:

1. A communication device comprising:

a first communication circuit contained in a first housing and configured for two-way speech communication according to a first communication protocol; and

a second communication circuit contained in a second housing and configured for two-way speech communication according to a second communication protocol, the second communication circuit further configured to be electrically coupled to the first communication circuit.

2. A communication device as recited in claim **1** wherein the first communication protocol is a cellular telephone protocol and the second communication protocol is a cordless telephone protocol.

3. A communication device as recited in claim **1** wherein the first communication circuit includes a transmitter, a receiver and an antenna, and wherein the second communication circuit includes a transceiver and an antenna.

4. A communication device as recited in claim **1** further comprising a connector for detachably coupling the first communication circuit and the second communication circuit.

5. A communication device as recited in claim **4** wherein the second housing comprises a detachable module.

6. A communication device as recited in claim **5** wherein the first housing comprises a radiotelephone operable according to the first communication protocol.

7. A communication device as recited in claim **6** wherein the communication device is operable in a primary mode according to the first communication protocol and is operable in a supplementary mode according to the second communication protocol, the communication device being selectively operable in one of the primary mode and the supplementary mode.

8. A communication device as recited in claim **6** wherein the communication device is operable in a primary mode according to the second communication protocol and is operable in a supplementary mode according to the first communication protocol, the communication device being selectively operable in one of the primary mode and the supplementary mode.

9. A communication device as recited in claim **6** wherein the first communication protocol is a cellular telephone protocol and the second communication protocol is a cordless telephone protocol.

10. A communication device comprising:

a first housing containing a first communication circuit configured for two-way communication of speech information according to a first communication protocol; and

a second housing containing a second communication circuit configured for two-way communication of speech information according to a second communication protocol, the second communication circuit electrically coupling with the first communication circuit when the second housing is joined with the first housing.

11. A communication device as recited in claim 10 wherein the first communication protocol is a cellular telephone protocol and the second communication protocol is a cordless telephone protocol.

12. A communication device as recited in claim 10 wherein the communication device further comprises a connector for electrically coupling the first communication circuit and the second communication circuit.

13. A communication device as recited in claim 12 wherein the second housing is detachably couplable to the second housing.

14. A communication device as recited in claim 13 wherein the first communication circuit includes a transmitter, a receiver, a microcomputer coupled to the transmitter and the receiver, a user interface coupled to the microcomputer, an antenna coupled to the transmitter and the receiver and a first connector portion coupled to the microcomputer, and wherein the second communication circuit includes a second connector portion and a transceiver, wherein the second connector portion electrically couples with the first connector portion when the second housing couples to the first housing.

15. A communication device as recited in claim 14 wherein the user interface comprises a keypad and a display.

16. A communication device as recited in claim 14 wherein the second communication device further comprises an antenna.

17. A radiotelephone comprising first and second communication circuits, each communication circuit providing speech communication according to first and second communication protocols, respectively, the second communication circuit configured as a plug-in accessory which couples via a connector to the first communication circuit.

18. A radiotelephone as recited in claim 17 wherein the first communication protocol is a cellular telephone protocol and the second communication protocol is a cordless telephone protocol.

19. A radiotelephone as recited in claim 17 wherein the connector comprises a first connector portion coupled to the first communication circuit and a second connector portion coupled to the second communication circuit, the second connector portion detachably plugging to the first connector portion.

20. A radiotelephone as recited in claim 19 further comprising a first housing containing the first communication circuit and the first connector portion and a second housing containing the second communication circuit and the second connector portion.

21. A radiotelephone as recited in claim 17 wherein the first communication circuit is configured for radio communication using a first frequency range and the second communication circuit is configured for radio communication using a second frequency range, the second frequency range being different from the first frequency range.

22. A communication device providing dual mode operation, the communication device comprising:

a first communication circuit contained in a first housing and including a transmitter and a receiver operable according to a first communication protocol for two-way communication of speech information with a first remote transceiver;

a second communication circuit contained in a second housing and including a transmitter and a receiver operable according to a second communication protocol for two-way communication of speech information with a second remote transceiver; and

a connector for electrically coupling the first communication circuit and the second communication circuit when the first housing and the second housing are joined.

23. A communication device as recited in claim 22 wherein the first communication protocol is a cellular telephone protocol and the second communication protocol is a cordless telephone protocol.

24. A communication device as recited in claim 22 wherein the communication device is operable in a primary mode according to the first communication protocol and is operable in a supplementary mode according to the second communication protocol, the communication device being selectively operable in one of the primary mode and the supplementary mode.

25. A communication device as recited in claim 23 wherein the second housing comprises a module detachable from the first housing.

26. A communication device as recited in claim 25 wherein the first housing and the first communication circuit form an independently operable radiotelephone which operates in a primary mode to provide two-way speech communication with the first remote transceiver.

27. A communication device as recited in claim 26 wherein the second housing and the second communication circuit form a supplementary module which operates in a secondary mode to provide two-way speech communication with the second remote transceiver when speech communication with the first remote transceiver is not available.

28. A communication device as recited in claim 26 wherein the first communication circuit includes a transmitter, a receiver and an antenna and the second communication circuit includes a transceiver and an antenna.

* * * * *

US005842122A

United States Patent [19]

Schellinger et al.

[11] Patent Number: 5,842,122

[45] Date of Patent: *Nov. 24, 1998

[54] **APPARATUS AND METHOD FOR ALTERNATIVE RADIOTELEPHONE SYSTEM SELECTION**

[75] Inventors: **Michael J. Schellinger**, Bloomingdale; **Robert F. D'Avello**, Lake Zurich; **Robert K. Krolopp**, Chicago, all of Ill.

[73] Assignee: **Motorola, Inc.**, Schaumburg, Ill.

[*] Notice: The term of this patent shall not extend beyond the expiration date of Pat. No. 5,260,988.

[21] Appl. No.: **100,517**

[22] Filed: **Jul. 30, 1993**

Related U.S. Application Data

[63] Continuation of Ser. No. 832,063, Feb. 6, 1992, Pat. No. 5,260,988.

[51] **Int. Cl.**[6] **H04Q 7/36**

[52] **U.S. Cl.** **455/403**; 455/31.1

[58] **Field of Search** 379/56, 58, 59, 379/60, 61, 62; 455/31.1, 33.1, 34.1, 76, 54.1, 403; 375/250; 342/387; 340/825.34

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Primary Examiner—William Cumming

Attorney, Agent, or Firm—John J. King; Mark D. Patrick

[57] **ABSTRACT**

A dual mode cellular cordless portable radiotelephone preferentially selects the cordless base station over the cellular system when in range of the cordless base station. When the cordless cellular portable is operating in the cellular mode, the radio channel associated with the cordless base station is sampled for a predetermined time. When a signal on the sampled cordless base station channel is detected, the cordless portable moves to the cordless mode and remains in the cordless mode for as long as the signal quality of the signal on the cordless base station channel exceeds a predetermined value.

2 Claims, 11 Drawing Sheets

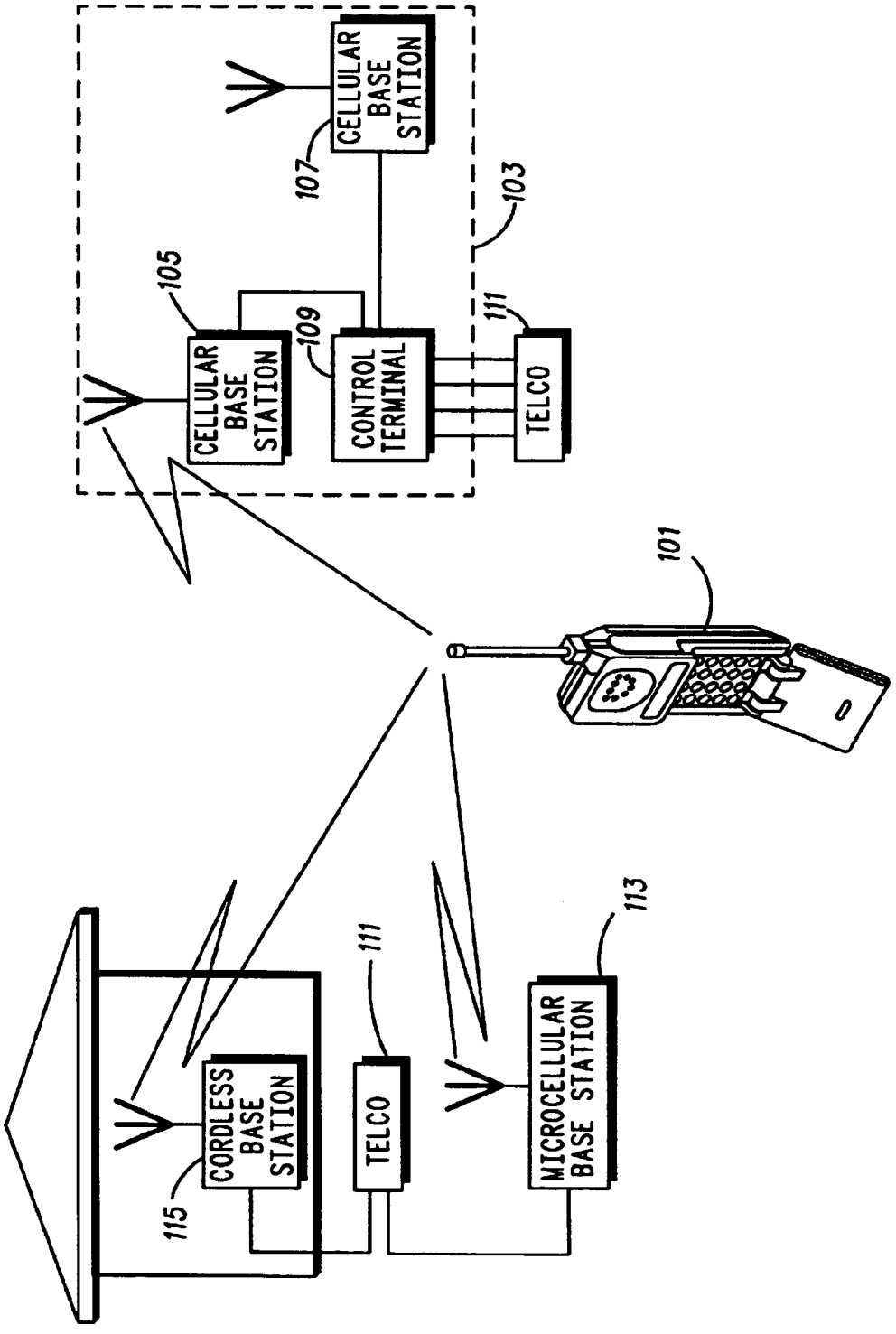

CELLULAR BASE STATION
107
103
105
109
111
CELLULAR BASE STATION
CONTROL TERMINAL
TELCO
101
113
111
CORDLESS BASE STATION
TELCO
MICROCELLULAR BASE STATION
115

FIG. 1

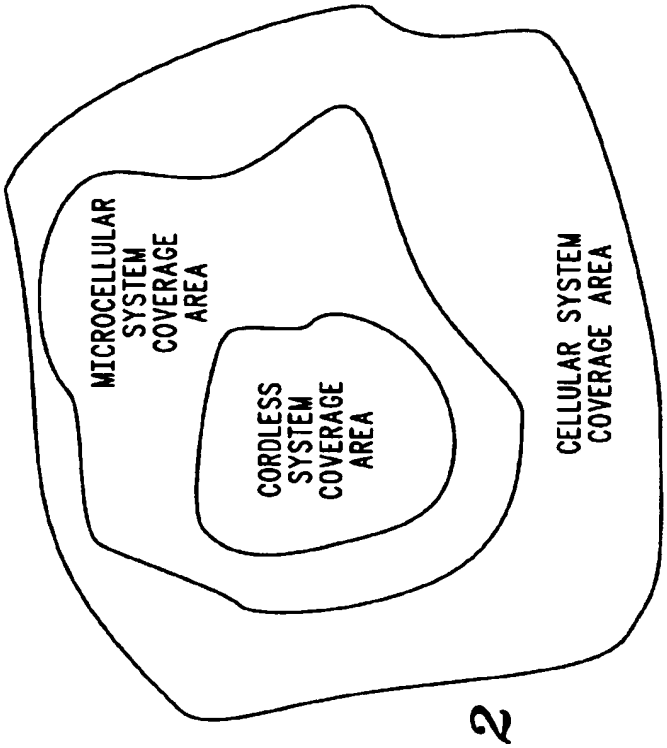


FIG. 2

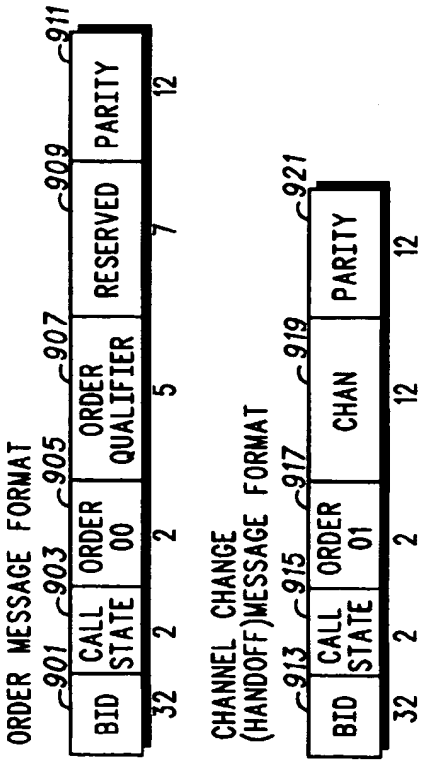


FIG. 9

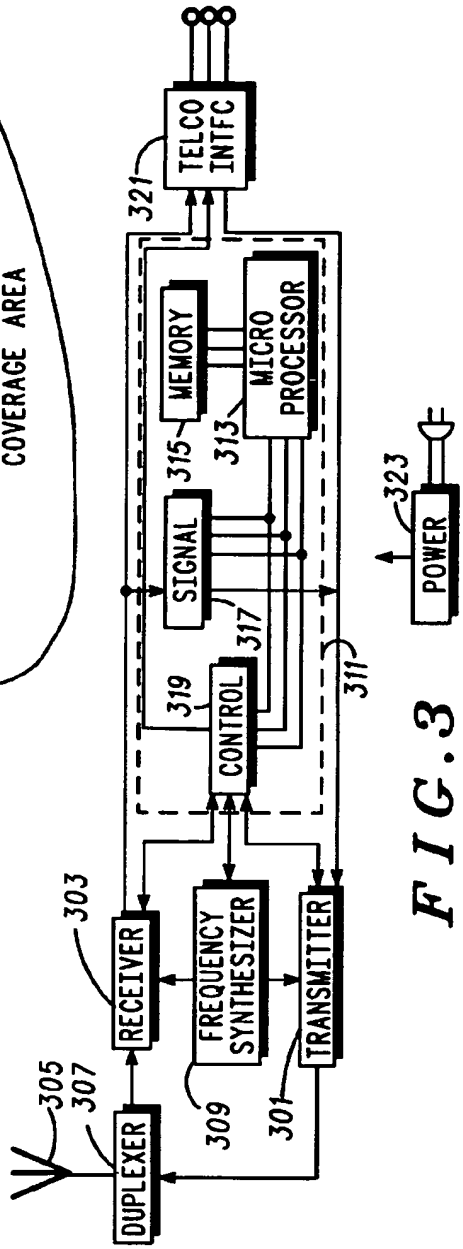


FIG. 3

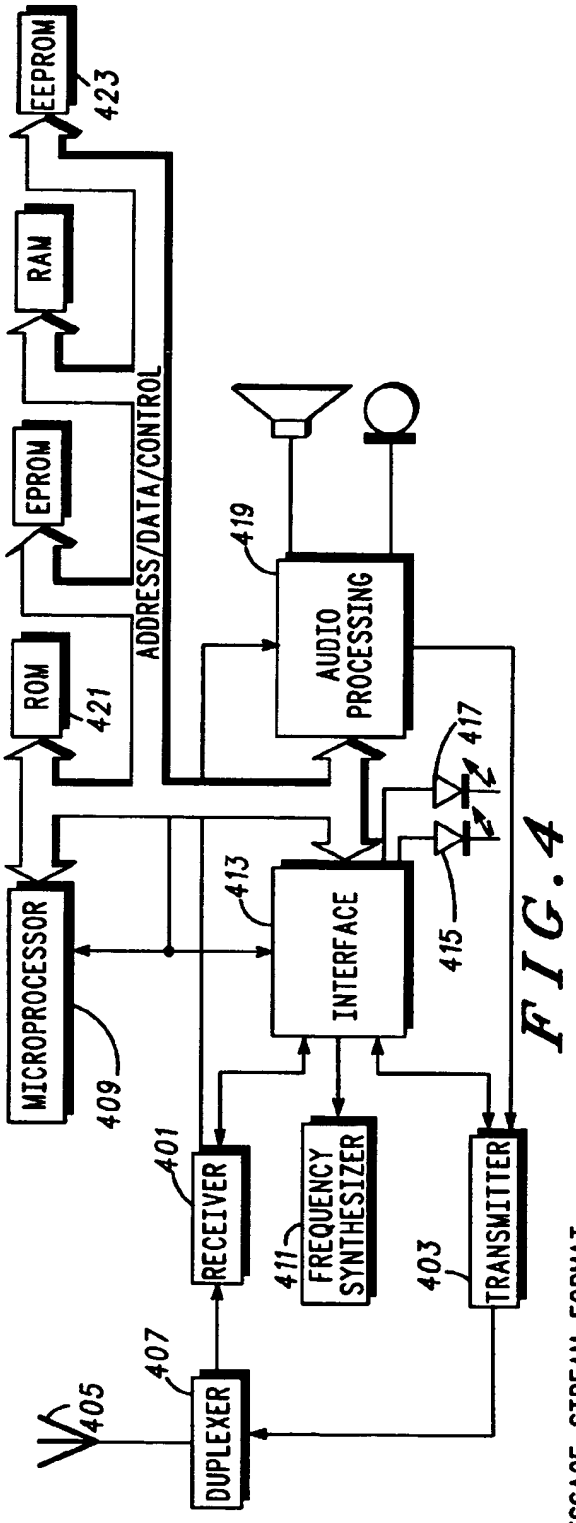


FIG. 4

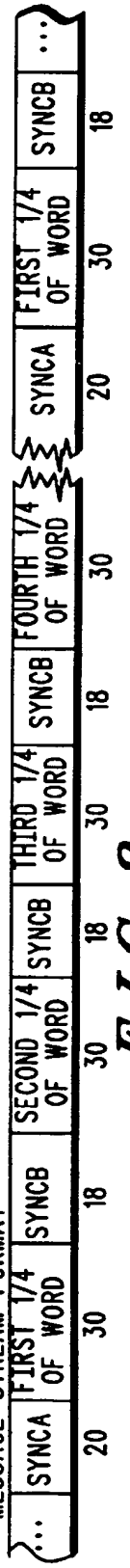


FIG. 8

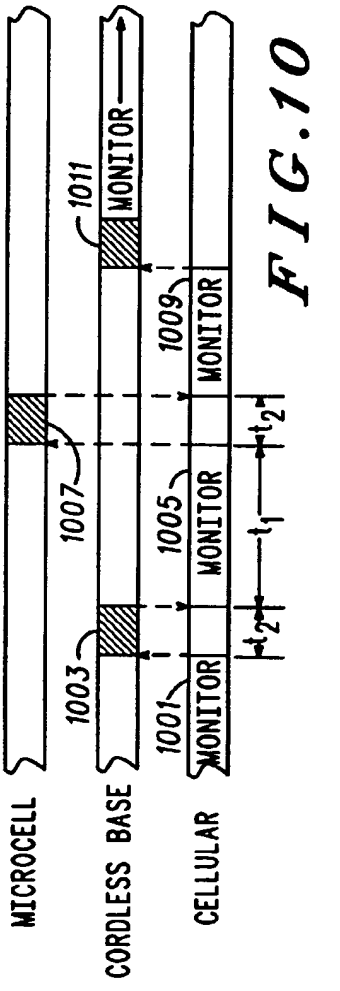
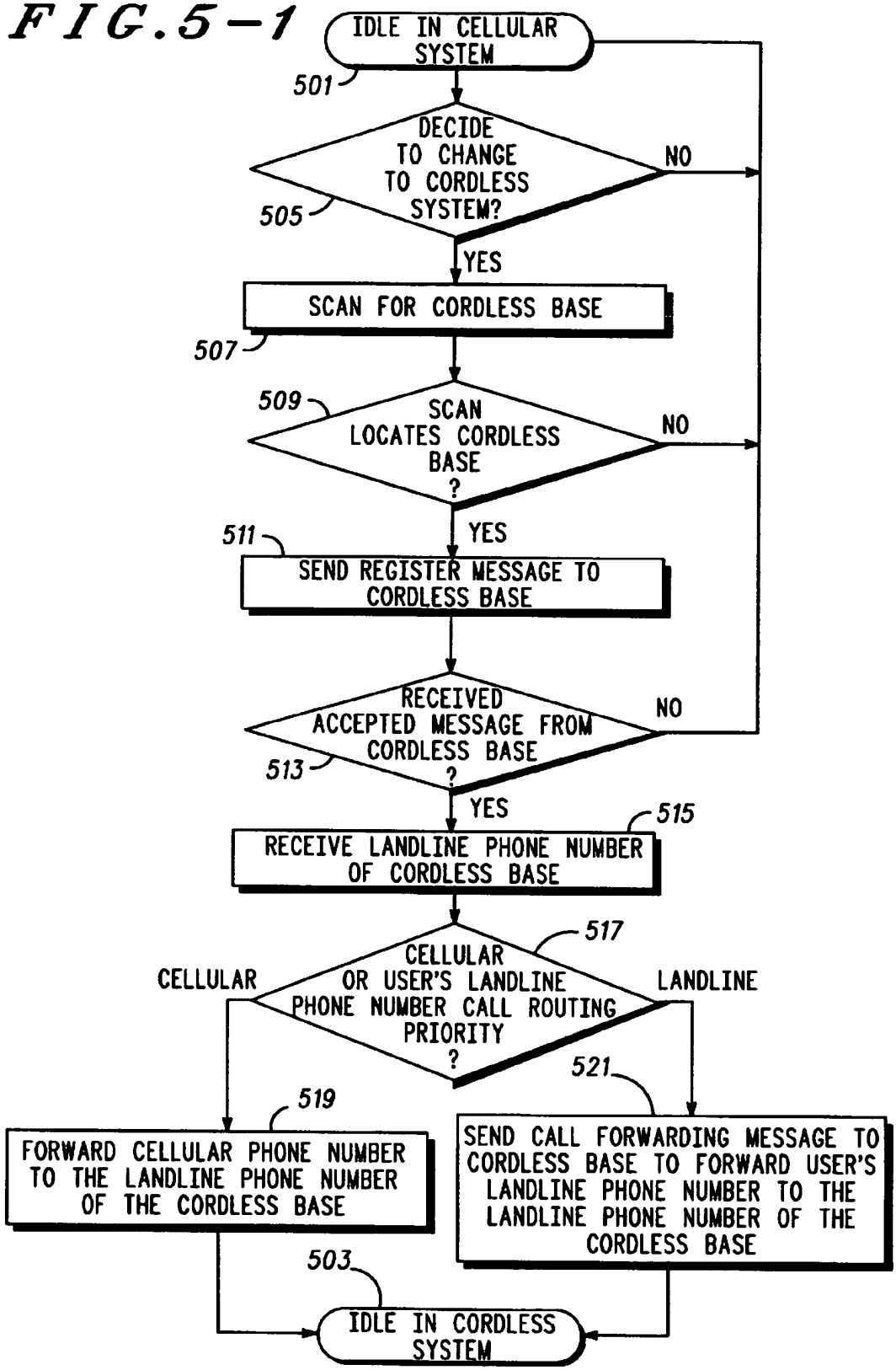


FIG. 10

FIG. 5-1


IDLE IN CELLULAR SYSTEM
501
DECIDE TO CHANGE TO CORDLESS SYSTEM?
505
NO
YES
SCAN FOR CORDLESS BASE
507
SCAN LOCATES CORDLESS BASE ?
509
NO
YES
SEND REGISTER MESSAGE TO CORDLESS BASE
511
RECEIVED ACCEPTED MESSAGE FROM CORDLESS BASE ?
513
NO
YES
RECEIVE LANDLINE PHONE NUMBER OF CORDLESS BASE
515
CELLULAR OR USER'S LANDLINE PHONE NUMBER CALL ROUTING PRIORITY ?
517
CELLULAR
LANDLINE
FORWARD CELLULAR PHONE NUMBER TO THE LANDLINE PHONE NUMBER OF THE CORDLESS BASE
519
SEND CALL FORWARDING MESSAGE TO CORDLESS BASE TO FORWARD USER'S LANDLINE PHONE NUMBER TO THE LANDLINE PHONE NUMBER OF THE CORDLESS BASE
521
IDLE IN CORDLESS SYSTEM
503

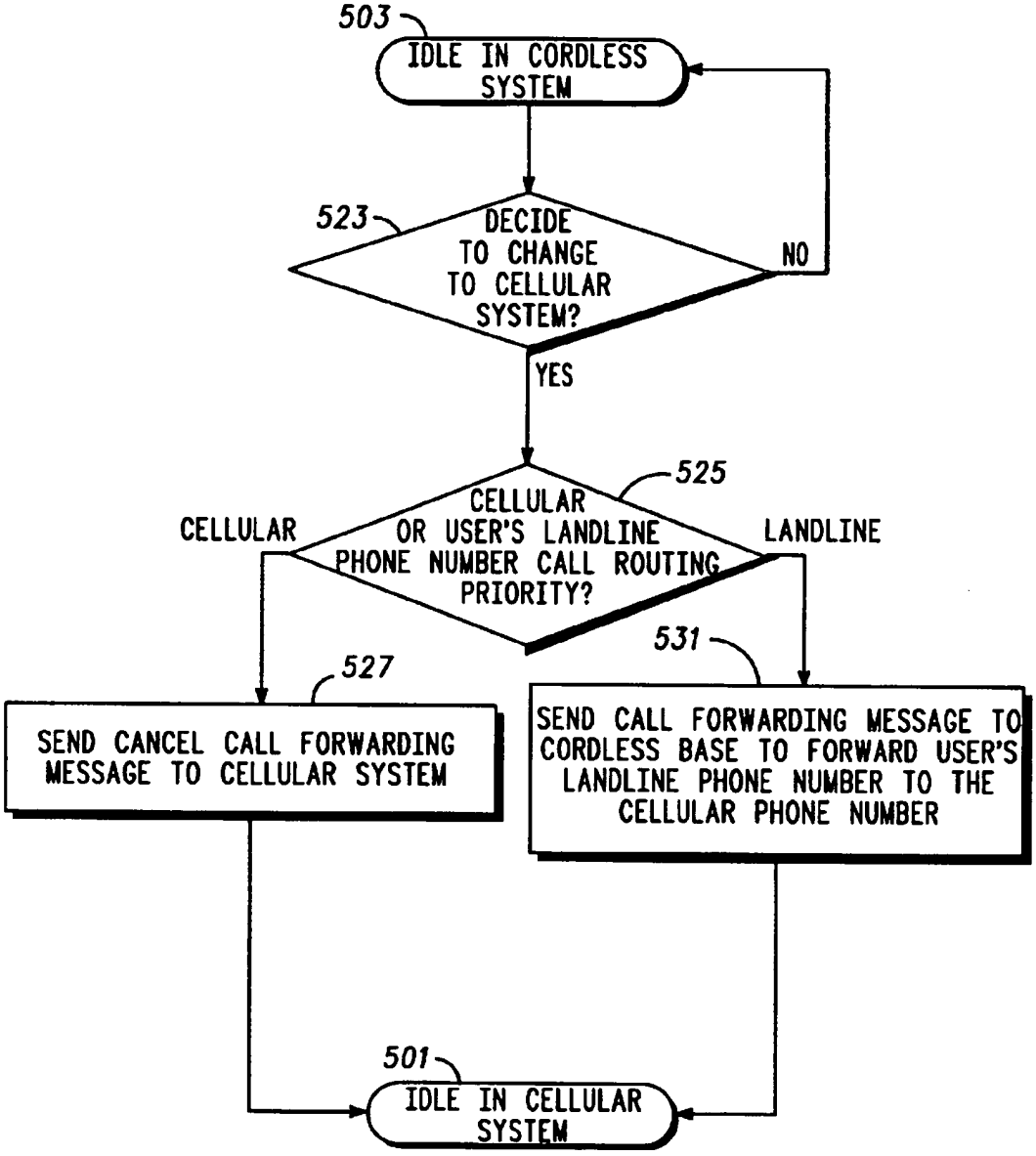

503
IDLE IN CORDLESS SYSTEM
523
DECIDE TO CHANGE TO CELLULAR SYSTEM?
NO
YES
525
CELLULAR OR USER'S LANDLINE PHONE NUMBER CALL ROUTING PRIORITY?
CELLULAR
LANDLINE
527
SEND CANCEL CALL FORWARDING MESSAGE TO CELLULAR SYSTEM
531
SEND CALL FORWARDING MESSAGE TO CORDLESS BASE TO FORWARD USER'S LANDLINE PHONE NUMBER TO THE CELLULAR PHONE NUMBER
501
IDLE IN CELLULAR SYSTEM

FIG. 5-2

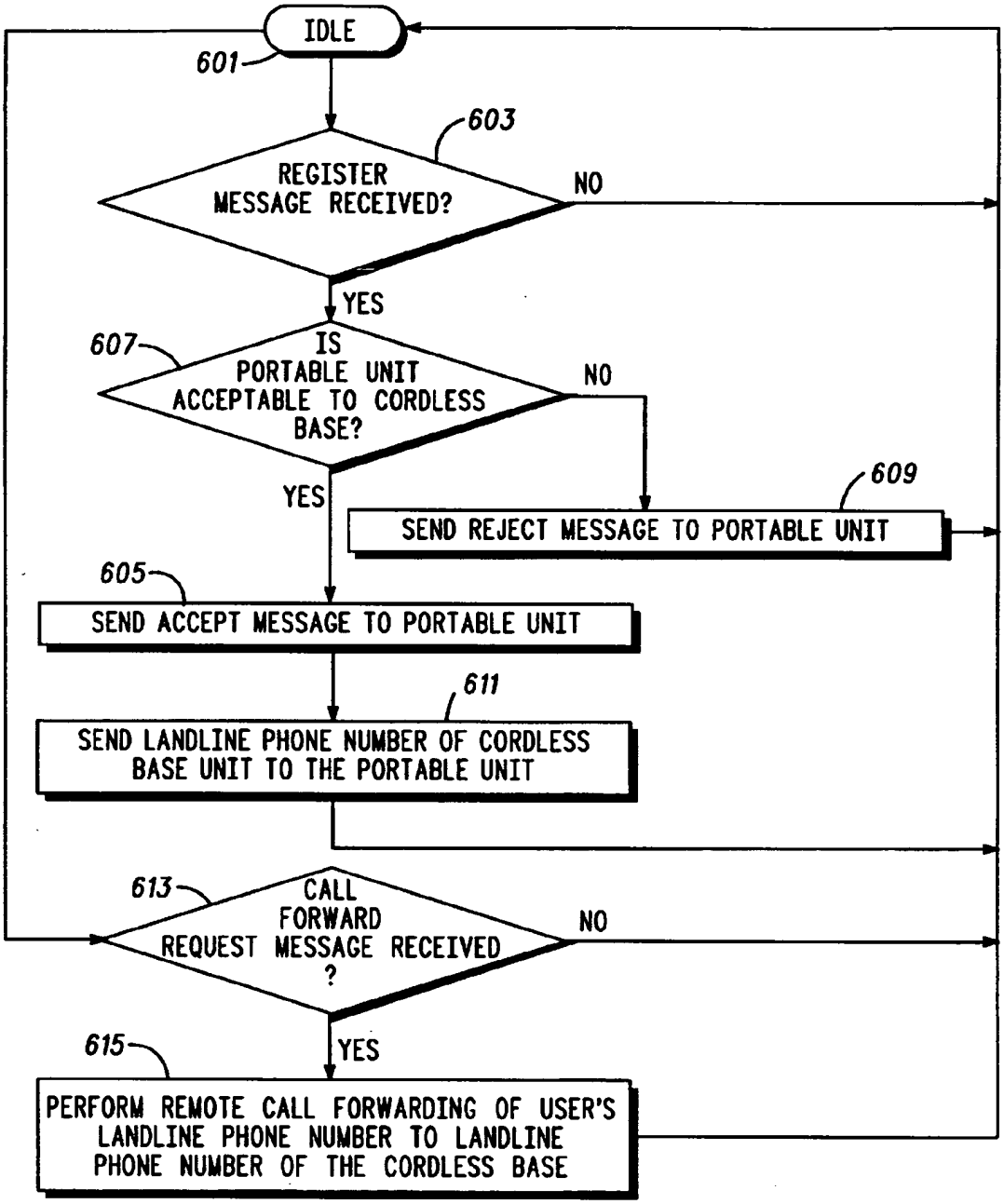

IDLE
601
603
REGISTER MESSAGE RECEIVED?
NO
YES
607
IS PORTABLE UNIT ACCEPTABLE TO CORDLESS BASE?
NO
YES
609
SEND REJECT MESSAGE TO PORTABLE UNIT
605
SEND ACCEPT MESSAGE TO PORTABLE UNIT
611
SEND LANDLINE PHONE NUMBER OF CORDLESS BASE UNIT TO THE PORTABLE UNIT
613
CALL FORWARD REQUEST MESSAGE RECEIVED ?
NO
YES
615
PERFORM REMOTE CALL FORWARDING OF USER'S LANDLINE PHONE NUMBER TO LANDLINE PHONE NUMBER OF THE CORDLESS BASE

FIG.6-1

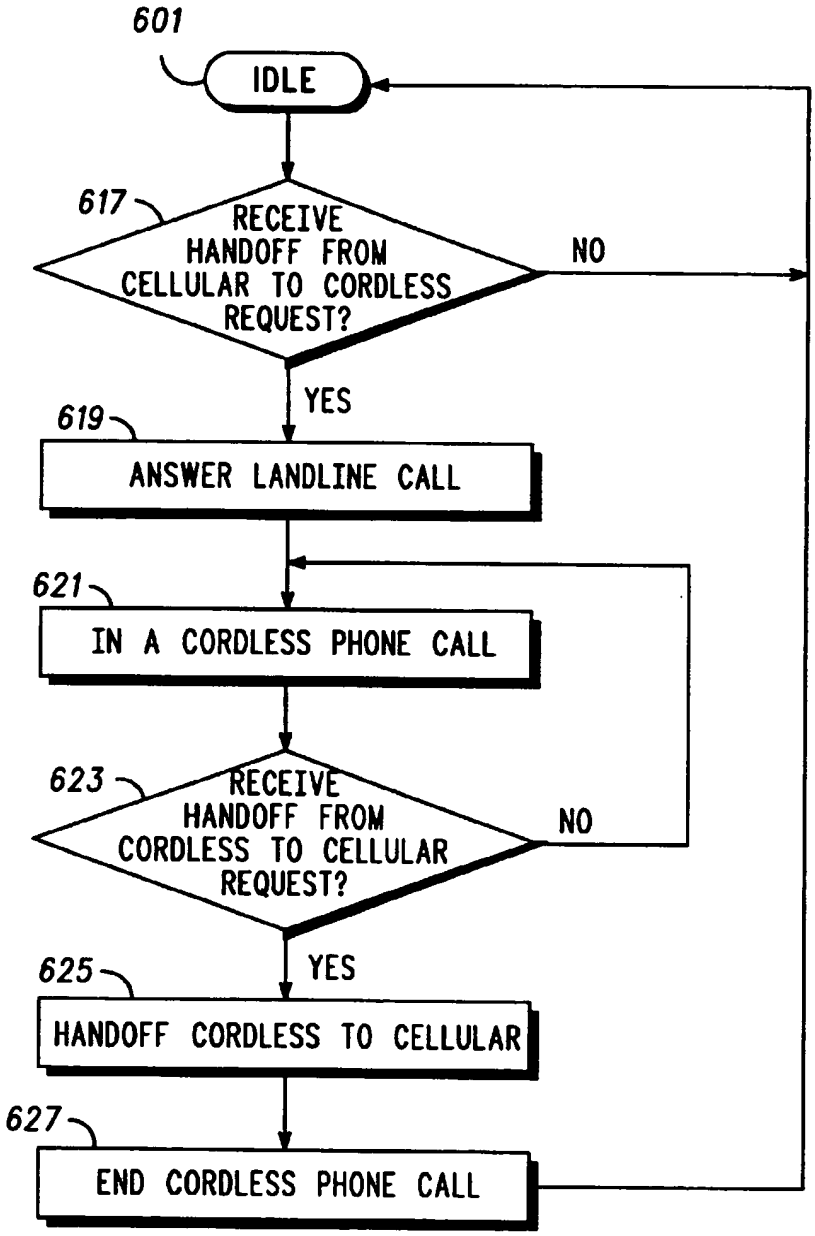

601
IDLE
617
RECEIVE HANDOFF FROM CELLULAR TO CORDLESS REQUEST?
NO
YES
619
ANSWER LANDLINE CALL
621
IN A CORDLESS PHONE CALL
623
RECEIVE HANDOFF FROM CORDLESS TO CELLULAR REQUEST?
NO
YES
625
HANDOFF CORDLESS TO CELLULAR
627
END CORDLESS PHONE CALL

FIG.6-2

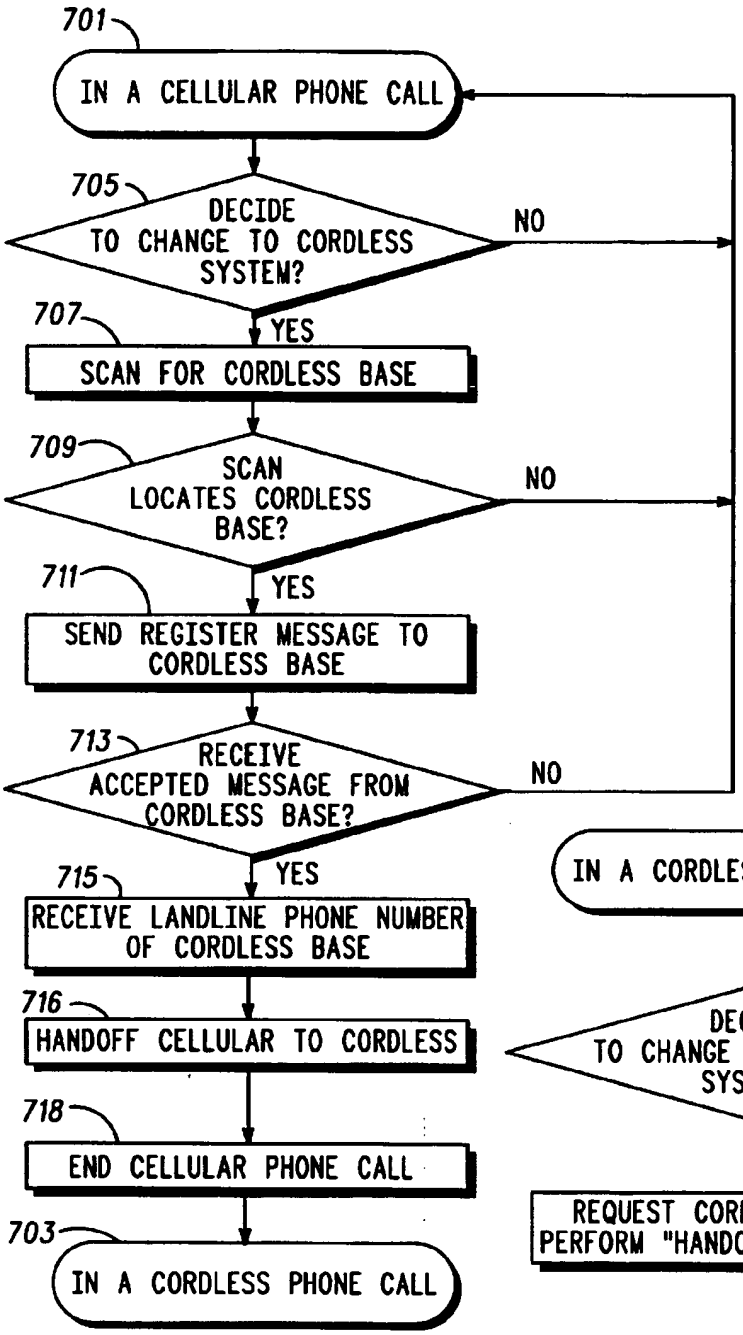

701
IN A CELLULAR PHONE CALL
705
DECIDE TO CHANGE TO CORDLESS SYSTEM?
NO
YES
707
SCAN FOR CORDLESS BASE
709
SCAN LOCATES CORDLESS BASE?
NO
YES
711
SEND REGISTER MESSAGE TO CORDLESS BASE
713
RECEIVE ACCEPTED MESSAGE FROM CORDLESS BASE?
NO
YES
715
RECEIVE LANDLINE PHONE NUMBER OF CORDLESS BASE
716
HANDOFF CELLULAR TO CORDLESS
718
END CELLULAR PHONE CALL
703
IN A CORDLESS PHONE CALL

FIG. 7-1

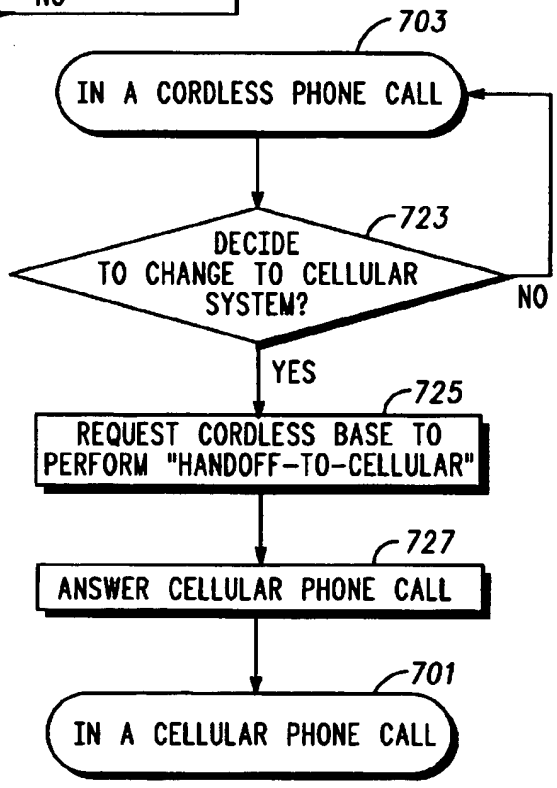

703
IN A CORDLESS PHONE CALL
723
DECIDE TO CHANGE TO CELLULAR SYSTEM?
NO
YES
725
REQUEST CORDLESS BASE TO PERFORM "HANDOFF-TO-CELLULAR"
727
ANSWER CELLULAR PHONE CALL
701
IN A CELLULAR PHONE CALL

FIG. 7-2

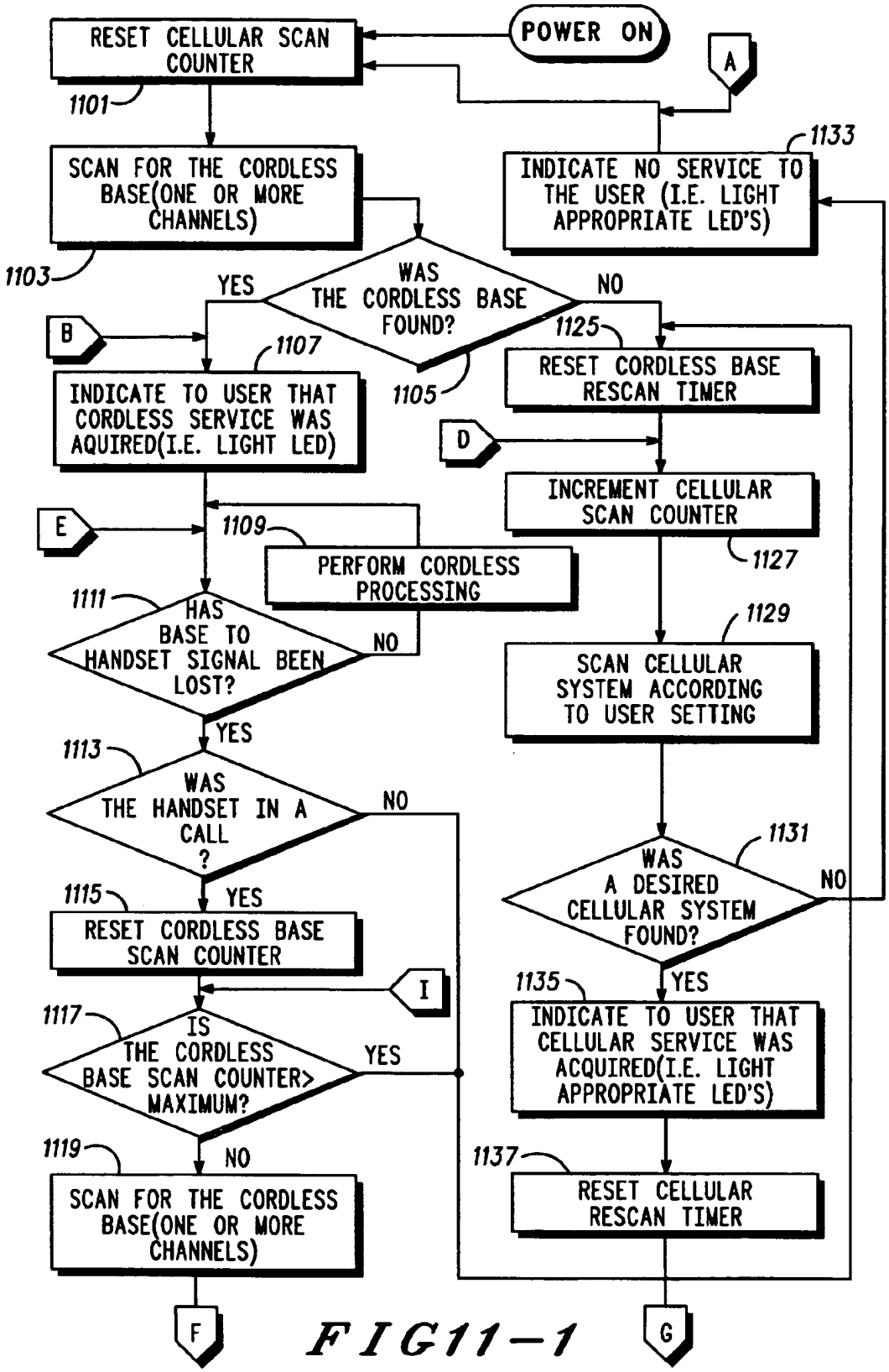
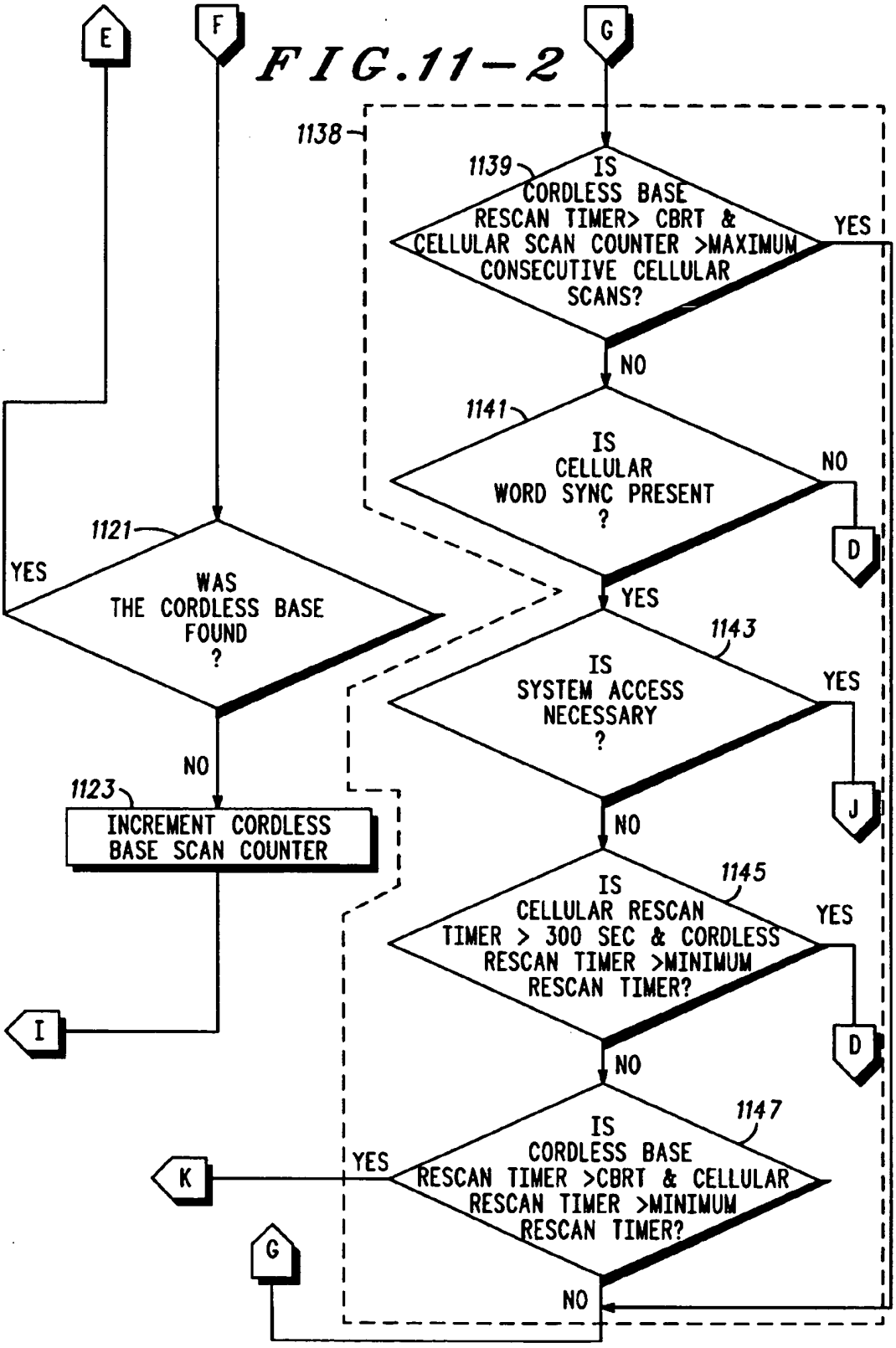

POWER ON
RESET CELLULAR SCAN COUNTER
1101
SCAN FOR THE CORDLESS BASE(ONE OR MORE CHANNELS)
1103
WAS THE CORDLESS BASE FOUND?
YES
NO
1105
B
1107
INDICATE TO USER THAT CORDLESS SERVICE WAS AQUIRED(I.E. LIGHT LED)
E
1109
PERFORM CORDLESS PROCESSING
1111
HAS BASE TO HANDSET SIGNAL BEEN LOST?
NO
YES
1113
WAS THE HANDSET IN A CALL ?
NO
YES
1115
RESET CORDLESS BASE SCAN COUNTER
I
1117
IS THE CORDLESS BASE SCAN COUNTER> MAXIMUM?
YES
NO
1119
SCAN FOR THE CORDLESS BASE(ONE OR MORE CHANNELS)
F
A
1133
INDICATE NO SERVICE TO THE USER (I.E. LIGHT APPROPRIATE LED'S)
1125
RESET CORDLESS BASE RESCAN TIMER
D
INCREMENT CELLULAR SCAN COUNTER
1127
1129
SCAN CELLULAR SYSTEM ACCORDING TO USER SETTING
1131
WAS A DESIRED CELLULAR SYSTEM FOUND?
NO
YES
1135
INDICATE TO USER THAT CELLULAR SERVICE WAS ACQUIRED(I.E. LIGHT APPROPRIATE LED'S)
1137
RESET CELLULAR RESCAN TIMER
G

FIG11-1

FIG. 11-2


E
F
G
1138
1139
IS CORDLESS BASE RESCAN TIMER> CBRT & CELLULAR SCAN COUNTER >MAXIMUM CONSECUTIVE CELLULAR SCANS?
YES
NO
1141
IS CELLULAR WORD SYNC PRESENT ?
NO
D
YES
1121
YES
WAS THE CORDLESS BASE FOUND ?
1143
IS SYSTEM ACCESS NECESSARY ?
YES
J
NO
1123
INCREMENT CORDLESS BASE SCAN COUNTER
NO
1145
IS CELLULAR RESCAN TIMER > 300 SEC & CORDLESS RESCAN TIMER >MINIMUM RESCAN TIMER?
YES
D
I
NO
1147
IS CORDLESS BASE RESCAN TIMER >CBRT & CELLULAR RESCAN TIMER >MINIMUM RESCAN TIMER?
YES
K
G
NO

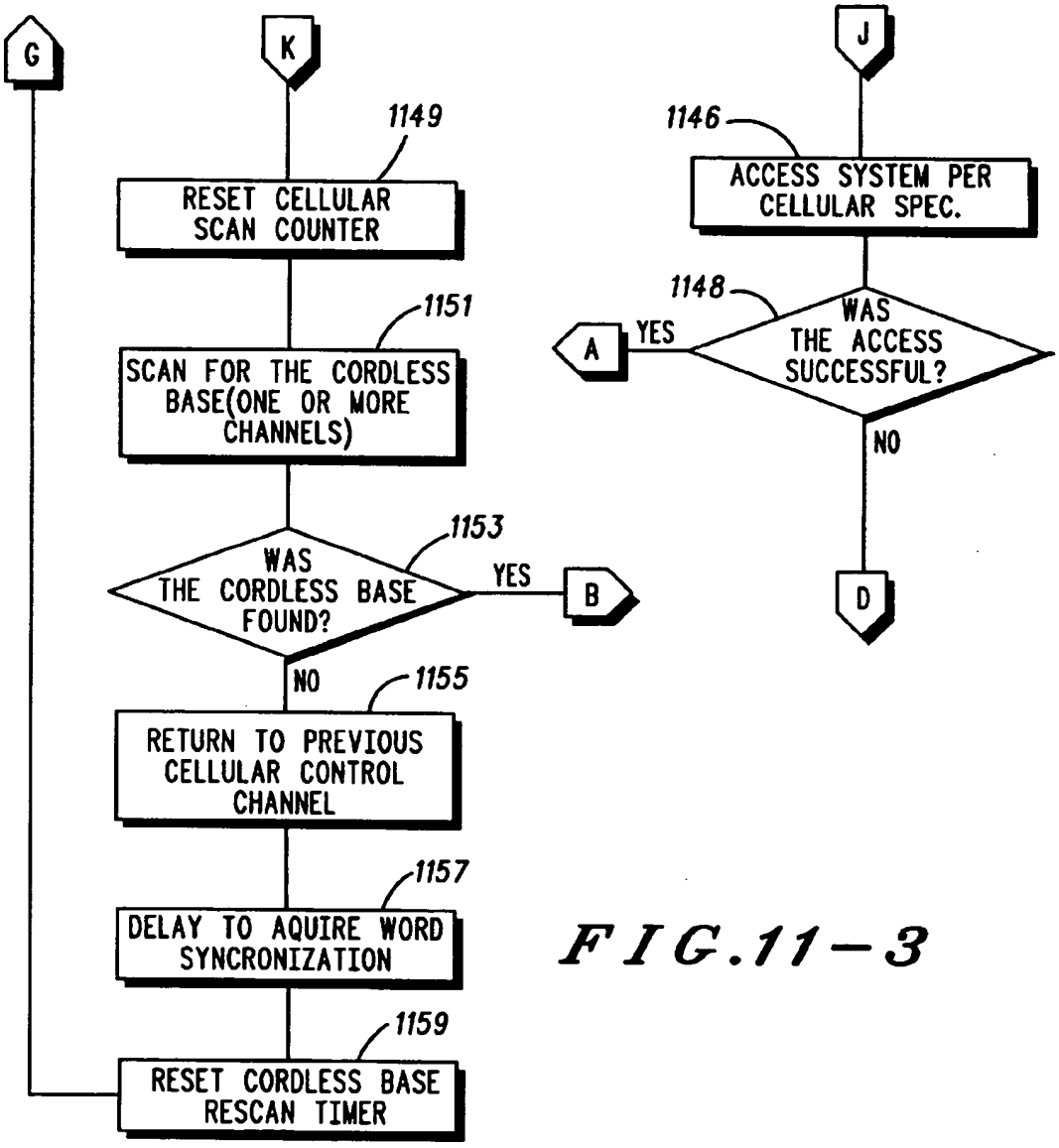

G
K
1149
RESET CELLULAR SCAN COUNTER
1151
SCAN FOR THE CORDLESS BASE(ONE OR MORE CHANNELS)
1153
WAS THE CORDLESS BASE FOUND?
YES
B
NO
1155
RETURN TO PREVIOUS CELLULAR CONTROL CHANNEL
1157
DELAY TO AQUIRE WORD SYNCRONIZATION
1159
RESET CORDLESS BASE RESCAN TIMER
J
1146
ACCESS SYSTEM PER CELLULAR SPEC.
1148
WAS THE ACCESS SUCCESSFUL?
A
YES
NO
D

FIG.11-3

APPARATUS AND METHOD FOR ALTERNATIVE RADIOTELEPHONE SYSTEM SELECTION

This is a continuation of application Ser. No. 07/832,063, filed Feb. 6, 1992, and now U.S. Pat. No. 5,260,988.

FIELD OF THE INVENTION

The present invention relates generally to portable telephones, and more particularly to an improved portable telephone that may receive calls in both cordless and cellular telephone systems.

BACKGROUND OF THE INVENTION

A cordless telephone system typically includes a portable cordless handset and a cordless base station connected to a telephone company phone system (TELCO) by telephone landlines. The cordless base station has an assigned landline telephone number that allows the user to place and receive calls using the cordless portable handset within a limited range of the cordless base station, such as in a home. However, due to their limited range, the cordless portable handset provides the user with relatively local radiotelephone communication.

Radiotelephone communication outside the range of the cordless telephone system may also be provided to the user via a cellular telephone system. A cellular telephone system typically includes cellular subscriber units (mobile or portable) and cellular base stations connected to the TELCO via one or more cellular switching networks. Each cellular subscriber unit has an assigned cellular telephone number that allows the user to place and receive calls within a widespread range of the cellular base stations, such as throughout a metropolitan area. However, the cost of using the cellular telephone service is much greater than the cordless telephone service.

A problem exists for the user that frequently relocates between the cordless and cellular telephone systems. An incoming call routed to the system where the user is not located may be missed. In the prior art, landline and cellular telephone companies have provided a solution to this problem with features known as No Answer Transfer or Call Forwarding or Three Way Calling. No Answer Transfer enables the user to program the system to route an incoming call from the cellular telephone system to the cordless telephone system or visa versa when the user's telephone that was called is not turned on, not answered, or out of range of the base station. Thus, the user may receive an incoming call placed to either the cordless or cellular telephone system.

Some problems exist with the No Answer Transfer feature. The user must manually program the system each time there is a need to activate or deactivate the No Answer Transfer feature. Manually programming the system is a cumbersome task for the user and forgetfulness of the user may result in missed or improperly routed incoming calls. The user must also purchase and operate unique radiotelephone equipment for both the cordless and cellular telephone systems resulting in increased cost and inconvenience to the user.

Furthermore, a portable radiotelephone which transmits and receives calls in both a cellular and a cordless system should have the capability to select which system it is to operate into. An automatic system selection should be made on parameters advantageous to the user. The user should also be able to override the automatic selection and pick a system manually.

Accordingly, there is a need for a radiotelephone system that enables a user to receive incoming calls via both a cordless and cellular telephone system without the imposing inconvenience and expense on the user.

SUMMARY OF THE INVENTION

System selection is preferentially realized for a radiotelephone apparatus which transmits and receives messages on a first radiotelephone system having a limited radio coverage area. Alternatively, system selection of a second radiotelephone system having a wide radio coverage area may be made when a radio channel associated with the first radiotelephone system is determined to be unavailable. A radio channel associated with the second radiotelephone system is monitored for a first predetermined period of time when the radio channel associated with the first radiotelephone system has been determined to be unavailable. A signal quality of a signal on said radio channel associated with the first radiotelephone system is sampled for a second predetermined period of time following said first predetermined period of time. This radio channel associated with the first radiotelephone system is monitored for as long as the signal quality of the signal exceeds a predetermined value.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. **1** is a block diagram of an operating configuration for a portable radiotelephone in which several systems, including both a cellular system and a cordless system, may be accessed by the same portable radiotelephone.

FIG. **2** is a diagrammatical map which shows a typical arrangement of coverage areas for the cordless, microcellular and cellular systems.

FIG. **3** is a block diagram of a cordless base station which may employ the present invention.

FIG. **4** is a block diagram of a portable radiotelephone which may employ the present invention.

FIGS. **5-1** and **5-2** are flowcharts for the process used by the portable radiotelephone of FIG. **4** when the portable radiotelephone is not in a call.

FIG. **6-1** is a flowchart for the process used by the cordless base station of FIG. **3** when the portable radiotelephone is not in a call.

FIG. **6-2** is a continuation of the flowchart in FIG. **6-1** for the process used by the cordless base station of FIG. **3** when the portable radiotelephone is in a call.

FIGS. **7-1** and **7-2** are flowcharts for the process used by the portable radiotelephone of FIG. **4** when the portable radiotelephone is in a call.

FIG. **8** is a message stream format which may be transmitted from the cordless base station of FIG. **3**.

FIG. **9** is a format diagram of an order message and a channel change message which may comprise part of the message stream format of FIG. **8**.

FIG. **10** is a timing diagram of the system scanning process which may be employed in the portable radiotelephone of FIG. **4**.

FIGS. **11-1**, **11-2** and **11-3** are, together, a flowchart diagramming the process of system priority selection which may be employed in the portable radiotelephone of FIG. **4**.

DETAILED DESCRIPTION OF A PREFERRED EMBODIMENT

A generalized block diagram of an application of the present invention is shown in FIG. **1**. A portable cellular

cordless (PCC) radiotelephone **101** is shown having the ability to communicate with a conventional cellular radiotelephone system **103**, which has a plurality of cellular base stations **105, 107** located at geographically separate locations but arranged to provide radiotelephone coverage over a wide geographic area. The cellular base stations are coupled to a control terminal **109** which provides coordination among the plurality of cellular base stations, including handoff of user cellular mobile and portable equipment, and provides call switching and interconnect to the public switched telephone network (identified hereinafter as "TELCO") **111**.

The PCC **101** further has the capacity to communicate with a microcellular base station **113**, which is a cellular adjunct cell having lower power and limited capabilities but providing public radiotelephone service to distinct areas such as shopping malls, airports, etc. The microcellular base station **113** is coupled to the TELCO **111** landline telephone system so that calls can be placed to the TELCO.

The PCC **101** further has the capability to communicate with and place radiotelephone calls via a cordless base station **115**, which provides private telephone line interconnection to the TELCO **111** for the user of the PCC **101**. As previously noted, the cordless base station **115** and the PCC **101** together provide the limited radio range service conventionally known as cordless telephone service. Such service has become pervasive, conventionally using a few radio frequency channels in the HF (high frequency) radio band.

The user of a radiotelephone should expect that radiotelephone service be available wherever he travels in the United States and that this service is provided at the lowest cost. It is also to be expected that radiotelephone service be provided in a portable unit that is as compact and inexpensive as possible. The PCC **101** is uniquely configured to meet this end. Furthermore, the cordless base station **115** is uniquely designed to provide telephone interconnect to the user's home telephone line when the user has the PCC **101** within the radio range of the cordless base station **115**.

FIG. **2** shows a typical arrangement of coverage areas for the cordless, microcellular and cellular systems. The cordless system coverage area is the smallest and resides within the microcellular system. The microcellular system has intermediate coverage and resides within the cellular system. The coverage area of each system may depend upon but is not limited to the number of base stations in each system, antenna height of each base station and the power level used by each system. The user of the portable radiotelephone may relocate between the various coverage areas. The portable radiotelephone may change between systems based on but not limited to portable radiotelephone location, system availability, and user preference.

The coverage areas of the systems are not limited to the particular arrangement as shown in FIG. **2**. A coverage area may be independent of another coverage area or may partially overlap one or more other coverage areas.

Considering again, FIG. **1**, the cordless base station **115**, conceptually, is a subminiature cellular system providing a single signalling channel which transmits outbound data messages in a fashion analogous to a conventional cellular outbound signalling channel, and receives service requests from a remote unit, such as a PCC **101**. Proper service requests are granted with an assignment of a voice channel (made via the control channel) on the same or a second radio frequency to which the PCC **101** is instructed to time for its telephone call.

The basic implementation of a cordless base station is shown in FIG. **3**. A conventional transmitter **301** and a conventional receiver **303** suitable for use in the 869 to 894 MHz and 824 to 849 MHz band of frequencies, respectively, being used for conventional cellular services, are coupled to a common antenna **305** via a duplexer **307**. The power output of the transmitter **301** is limited to approximately 6 milliwatts so that interference to other services and other cordless telephone stations is minimized. The channel frequency selection is implemented by a frequency synthesizer **309** controlled by a logic unit **311**. Within the logic unit **311** is a microprocessor **313**, such as a 68HC11 available from Motorola, Inc., or similar microprocessor, which is coupled to conventional memory devices **315** which store the microprocessor operating program, base identification (BID) and customizing personality, and other features. Received and transmitted data is encoded/decoded and coupled between the receiver **303**, the transmitter **301**, and the microprocessor **313** by signalling interface hardware **317**. The microprocessor instructions are conveyed and implemented by control hardware **319**. Interface with the user's home landline telephone line is conventionally accomplished via a TELCO interface **321**. Power is supplied from the conventional AC mains and backed-up with a battery reserve (all depicted as power **323**).

The PCC **101** is a portable radiotelephone transceiver which is shown in block diagram form in FIG. **4**. A portable radio receiver **401**, capable of receiving the band of frequencies between 869 and 894 MHz, and a portable transmitter **403**, capable of transmitting with low power (approximately 6 milliwatts in the preferred embodiment) on frequencies between 824 and 849 MHz, are coupled to the antenna **405** of the PCC **101** by way of a duplexer **407**. The particular channel of radio frequency to be used by the transmitter **403** and the receiver **401** is determined by the microprocessor **409** and conveyed to the frequency synthesizer **411** via the interface circuit **413**. Data signals received by the receiver **401** are decoded and coupled to the microprocessor **409** by the interface circuit **413** and data signals to be transmitted by the transmitter **403** are generated by the microprocessor **409** and formatted by the interface **413** before being transmitted by the transmitter **403**. Operational status of the transmitter **403** and the receiver **401** is enabled or disabled by the interface **413**. The interface also controls light emitting diodes, **415** and **417**, which are used to indicate to the user which system the PCC **101** is currently receiving. Control of user audio, the microphone output and the speaker input, is controlled by audio processing circuitry **419**.

In the preferred embodiment, the microprocessor **409** is a 68HC11 microprocessor, available from Motorola, Inc., and performs the necessary processing functions under control of programs stored in conventional ROM **421**. Characterizing features of the PCC **101** are stored in EEPROM **423** (which may also be stored in microprocessor on-board EEPROM) and include the number assignment (NAM) required for operation in a conventional cellular system and the base identification (BID) required for operation with the user's own cordless base.

The transmitter **403** of the PCC **101** has the capability of transmitting with the full range of output power which is required for operation in a conventional cellular system. This range of output power consists of six sets of output power magnitude ranging from a high output power level of approximately 600 milliwatts to a low output power level of 6 milliwatts. This six set range of output power is enabled when the PCC **101** is in the cellular system mode.

According to the preferred embodiment of the present invention, the same PCC **101** is compatible with both the

cordless and cellular telephone system **103**. This is accomplished by enabling the PCC **101** to operate in both a cordless and cellular telephone system **103** using only cellular telephone frequencies.

The radiotelephone arrangement has desirable advantages for the user. Firstly, the PCC **101**, in combination with the cordless base station **115**, can automatically route an incoming call to the telephone system in which the PCC **101** is located without inconveniencing the user. Secondly, the PCC **101**, in combination with the cordless base station **115**, can automatically route a call in process with the PCC **101** between the cordless and the cellular telephone systems when the PCC **101** relocates therebetween.

FIGS. **5-1** and **5-2** are flowcharts for the process used by the PCC **101** in FIG. **4**. FIG. **6-1** is a flowchart in the process used by the cordless base station **115** in FIG. **3**. In one embodiment of the present invention, the PCC **101** and the cordless base station **115** cooperatively operate, as described in the flowcharts in FIGS. **5-1** and **5-2**, and **6-1**, respectively, to route an incoming call to the cordless telephone system or the cellular telephone system **103** according to the location of the PCC **101**.

As shown in FIG. **5-1**, the PCC **101** may be in an idle state in either the cellular telephone system **103** at block **501** or the cordless telephone system at block **503**. In either idle state, the PCC **101** is in a condition to receive an incoming call. For discussion purposes, assume that the PCC **101** is in the idle state in the cellular telephone system **103** at block **501**. The PCC **101** decides at block **505** whether to remain in its idle state in the cellular telephone system **103** by retuning to block **501** or to change to the cordless telephone system by scanning for an acceptable cordless base station at block **507**. If the scan process locates an acceptable cordless base station **115**, as determined at block **509**, the PCC **101** sends a register message (an attempt by the PCC to register with the cordless base station) to the cordless base station **115** at block **511**. Otherwise, the PCC **101** returns to the idle state in the cellular telephone system at block **501**.

In FIG. **6-1** the cordless base station **115** normally waits in an idle state at block **601**. Upon receiving the register message at block **603**, the cordless base station **115** determines if the PCC **101** is acceptable at block **607**. If no register message is received at block **603**, the cordless base station **115** returns to its idle state at block **601**. If the PCC **101** is acceptable, the cordless base station **115** sends an accept message to the PCC **101**, at block **605**, sends its own landline telephone number to the PCC **101**, at block **611**, and returns to its idle state at block **601**. If the PCC **101** is not accepted by the cordless base station **115**, at block **607**, the cordless base station **115** sends a reject message (a non-registration of the PCC by the cordless base station) to PCC **101** at block **609** and returns to its idle state at block **601**.

In FIG. **5-1** the PCC **101** determines if the accepted (PCC registration) message is received at block **513**. If the accepted message is received, the PCC **101** receives the landline telephone number of the cordless base station **115** at block **515**. Otherwise, the PCC **101** returns to its idle state in the cellular telephone system **103** at block **501**. Thus, the cordless base station **115** has been notified of the PCC's **101** decision to change to the cordless telephone system and the cordless base station **115** responds by giving the PCC **101** its landline telephone number.

In FIG. **5-1** the PCC **101** determines whether the user's cellular or landline phone number has call routing priority at block **517**. Call routing priority refers to the user's system preference (cellular or landline) to which an incoming call is routed to first before transfering to the second system if the PCC **101** is not located. Since the user is available via both a cellular and landline phone number, it would be convenient to give out only one of the phone numbers to another party to place incoming calls to the user. Thus, a single phone number may be used by the other party to reach the user's PCC **101** in either the cellular or cordless telephone system.

If the cellular phone number has call routing priority, the PCC **101** forwards the cellular phone number to the landline phone number of the cordless base unit at block **519** and waits in the idle state in the cordless telephone system at block **503**. Thus, an incoming call routed to the user's cellular phone number is automatically forwarded to the landline phone number of the cordless base station **115** when the PCC **101** is located in the cordless telephone system.

If the user's landline phone number has call routing priority, the PCC **101** sends a call forward message to the cordless base unit instructing it to forward the users landline phone number (sent to the cordless base station) to the landline phone number of the cordless base unit at block **521** and waits in the idle state in the cordless telephone system at block **503**. In FIG. **6-1**, if a call forward message is received by the cordless base station **115** at block **613**, the cordless base station **115** performs a remote call forwarding of the user's landline phone number to the landline phone number of the cordless base station **115** at block **615** and returns to its idle state at block **601**. Thus, an incoming call routed to the user's landline phone number is automatically forwarded to the landline phone number of the cordless base station **115** when the PCC **101** is located in the cordless system. If the PCC **101** is turned off the user may still receive incoming calls via any telephone associated with the phone number of the base station.

In FIG. **5-2** the PCC **101** decides at block **523** whether to remain in its idle state in the cordless telephone system by returning to block **503** or to change to the cellular telephone system **103** by progressing to block **525**. At block **525** the PCC **101** determines whether the cellular phone number of the PCC **101** or the user's landline phone number has call routing priority. If the cellular phone number has call routing priority, the PCC **101** sends a cancel call forwarding message to the cellular system and the PCC **101** returns to-waiting in the idle state in the cellular system at block **501**. Thus, an incoming call routed to the user's cellular phone number directly calls the PCC **101** located in the cellular telephone system **103**.

If the user's landline phone number has call routing priority, the PCC **101** sends a call forwarding message to the cordless base station **115** to forward the user's landline phone number for the cellular phone number of the PCC **101** at block **531**. If the PCC **101** is unable to establish communication with the cordless base station **115**, the PCC **101** can perform the call forwarding by making a cellular telephone call. Thus, an incoming call routed to the user's landline phone number is forwarded to the cellular phone number of the PCC **101** located in the cellular telephone system **103**.

FIGS. **7-1** and **7-2** are flowcharts for an alternate process used by the PCC **101** in FIG. **4**. FIG. **6-2** is a continuation of the flowchart in FIG. **6-1** for the process used by the cordless base station **115** in FIG. **3**. In an alternate embodiment of the present invention, the PCC **101** and the cordless base station **115** cooperatively operate, as described in the flowcharts in FIGS. **7-1** and **7-2**, and **6-2**, respectively, to automatically route a call in process (i.e. hand off a call) between the cordless telephone system and the cellular telephone system **103** when the location of PCC **101** moves

out of range of the cordless telephone system and is in the coverage area of the cellular telephone system **103**, respectively. An advantage of the automatic handoff operation to the user is transparent operation of the PCC **101** between the cordless and cellular telephone systems while the PCC **101** is in a call. Another advantage of the automatic handoff operation to the user is lower cost operation of the cordless telephone service. When the PCC **101** is within range of an acceptable cordless base station **115** the PCC **101** transfers from the cellular telephone system **103** to the cordless telephone system.

As shown in FIG. **7-1**, the PCC **101** may be in a call in either the cellular telephone system **103** at block **701** or the cordless telephone system at block **703**. For discussion purposes, assume that the PCC **101** is in a call in the cellular telephone system **103** at block **701**. The PCC **101** decides at block **705** whether to remain in its call state in the cellular telephone system **103** by returning to block **701** or to change to the cordless telephone system by scanning for an acceptable cordless base station **115** at block **707**. If the scan process locates an acceptable cordless base station **115**, as determined at block **709**, the PCC **101** sends a register message to the cordless base station **115** at block **711**. Otherwise, the PCC **101** returns to the call state in the cordless telephone system at block **701**.

In FIG. **6-1** the cordless base station **115** normally waits in an idle state at block **601**. Upon receiving the register message at block **603**, the cordless base station **115** determines if the PCC **101** is acceptable at block **607**. If no register message is received at block **603**, the cordless base station **115** returns to its idle state at block **601**. If the PCC **101** is acceptable, the cordless base station **115** sends an accept message to the PCC **101**, at block **605**, and sends its own landline telephone number to the PCC **101**, at block **611**, and returns to its idle state at block **601**. If the PCC **101** is not accepted by the cordless base station **115**, at block **607**, the cordless base station **115** sends a reject message to PCC **101** at block **609** and returns to its idle state at block **601**.

In FIG. **7-1** the PCC **101** determines if the accepted message is received at block **713**. If the accepted message is received, the PCC **101** receives the landline telephone number of the cordless base station **115** at block **715**. Otherwise, the PCC **101** returns to its call state in the cellular telephone system **103** at block **701**. Thus, the cordless base station **115** has been notified of the PCC **101**'s decision to change to the cordless telephone system and the cordless base station **115** responds by giving the PCC **101** its landline telephone number.

In accordance with the preferred embodiment of the present invention, a call in process between the PCC **101** operating in a cellular telephone system **103** and a calling party is handed off from the cellular telephone system **103** to the cordless telephone system by producing a three way call through the cellular telephone system **103**, at block **716**, between the PCC **101**, the other party and the landline phone number of the cordless base station **115**.

In FIG. **6-2** the cordless base station **115** receives the handoff from cellular to cordless request at block **617** and answers the landline leg of the three way call at block **619** to open communication between the other party and the cordless base station **115**. The PCC **101** is now in a cordless phone call with the calling party at block **621**. In FIG. **7A** the PCC **101** operating in the cellular telephone system **103** ends the cellular leg of the three way call at block **718** to terminate cellular system communication between the PCC **101** and the other party. Thus, a call in process is handed off from the cellular telephone system **103** to the cordless telephone system when the PCC **101** relocates from the cellular telephone system **103** to the cordless telephone system.

In FIG. **7-2** the PCC **101** decides at block **723** whether to remain in its call state in the cordless telephone system by returning to block **703** or to change to the cellular telephone system **103** by progressing to block **725**. At block **725**, the PCC **101** operating in a cordless telephone system requests that the cordless base station **115** perform a handoff from the cordless to cellular telephone system **103** by producing a three way call between the PCC **101**, the other party and the user's cellular phone number.

In FIG. **6-2** the cordless base unit determines if the request from the PCC **101** to handoff from the cordless to the cellular telephone system **103** at block **623** is received. If the request is received at block **623**, the cordless base unit performs a three way call between the PCC **101** operating in the cellular telephone system **103**, the other party and the landline phone number of the cordless base station **115** at block **625**. Otherwise, the cordless base station **115** returns to block **621** and remains in the call in the cordless telephone system. In FIG. **7-2** the PCC **101** answers the cellular leg of the three way call at block **727** to open communication between the PCC **101** operating in the cellular telephone system **103** and the other party. Thus, the PCC **101** is now in a cellular phone call at block **701**. In FIG. **6-2** the cordless base station **115** ends the landline leg of the three way call at block **627** to terminate communication between the calling party and the cordless base station **115** and returns to its idle state at block **601**.

The decision to change between the cordless and cellular telephone systems at blocks **505**, **523**, **705** and **723** may be based on a variety of factors including but not limited to: manually determined user preference, automatic system scanning preference or the radio's received signal quality. The PCC **101** may also scan for a number of cordless base station **115***s*, at blocks **509** and **709**, that are known to be acceptable to the PCC **101**.

Two embodiments of the present invention have been described. In the first embodiment, a radiotelephone arrangement has been described that enables an incoming call to be routed to a PCC **101** located in a cellular or cordless telephone system. In the alternate embodiment, a radiotelephone arrangement has been described that enables a call in process with the PCC **101** to handoff between the cellular and cordless telephone systems when the PCC **101** relocates therebetween. It is contemplated that a radiotelephone arrangement may include both embodiments of the present invention.

When the two embodiments are combined, there are some instances when call forwarding must be changed or cancelled before a three way call can be placed. In one example, the user's landline phone number has call routing priority. The PCC **101** is in a cellular telephone call and the PCC **101** decides to change to the cordless base station **115** connected to the user's landline telephone number. Call forwarding on the user's landline telephone number must be cancelled before a three way call can be placed to include the cordless base station **115**. In another example, the user's cellular phone number has call routing priority. The PCC **101** is in a cordless telephone call and the PCC **101** decides to change to the cellular telephone system **103**. Call forwarding on the user's cellular telephone number must be cancelled before a three way call can be placed to include the cellular telephone system **103**. In addition, call routing may be updated at the conclusion of the call in process. Thus, a single PCC **101**

may operate ubiquitously within a cellular and cordless telephone system.

The radiotelephone arrangement is not limited to only cellular and cordless telephone systems. The radiotelephone arrangement may operate in at least two radiotelephone systems where it would be desirable for a PCC **101** to switch between the systems. Such desirable reasons may include but are not limited to coverage area, service cost or service quality.

Since at least two systems coexist (the conventional cellular system and the cordless system) and have overlapping radio coverage, it is important that a priority hierarchy be established. The cordless system is expected to be a lower cost system than the conventional cellular system because it is attached via the user's home landline connection to the TELCO public switched telephone network by conventional wire. It is most likely that the cordless system would be the preferred system when the PCC **101** is within the coverage area of the cordless base station **115**. Therefore, in the preferred embodiment, priority is given to the cordless base service. However, the user may select other hierarchy of priority if desired.

The cordless base station **115** transmits an outbound signalling message on a radio channel which is selected to be noninterfering with radio channels in use in the local cellular system **103**. This message is similar to that transmitted in the conventional system in that its purpose is to present the identity of the cordless system and aid the PCC **101** in determining its availability. The format of the message outbound from the cordless base station **115** on its signalling channel is shown in FIG. **8**. Information is transmitted in NRZ format in which 20 bits of synchronization data bits (SYNCA) are followed by 30 bits of message word (comprising one-fourth the 120 NRZ bits of the entire message) followed by 18 bits of synchronization data bits (SYNCB), then 30 bits of message word. This format is continued for the four word segments to be transmitted. In the preferred embodiment, a continuation of the transmission of the next message word follows the fourth quarter of the message word with a SYNCA synchronization. An alternative embodiment provides a break between message words and their interleaved synchronization bits, thereby making the signalling channel transmissions discontinuous.

Two examples of the format for the message words are shown in FIG. **9**. Each message word is transmitted in Manchester format. Since a Manchester bit is comprised of two NRZ bits of opposite state, the 60 Manchester message bits are encoded in 120 NRZ bits. The first message word example is an order message which contains a 32 bit Base. IDentification field **901**, a Call State field **903**, an Order field **905**, an Order Qualifier field **907**, a field Reserved for future use **909**, and a Parity check field **911**. A second message word format example is a Channel Change (handoff) message also containing 60 bits. This message word also begins with a Base IDentification **913**, a Call State **915**, an Order **917**, a go-to Channel indication **919**, and a 12 bit Parity **921**. Each of the word messages has a leading Base IDentification (BID) field which operates in a manner similar to the conventional System IDentification (SID) in use in cellular systems. The BID, however, contains 32 bits rather than the 15 bits in the cellular system. The BED is programmed into the cordless base station memory **315** as a number unique to each cordless base station. This unique BID provides the special characterization of each cordless base station so that a user's PCC **101** and cordless base station **115** will operate together without allowing unauthorized users to obtain access.

In the preferred embodiment, the two bits of the Call State field are designated as follows: "00"—idle, no initialization allowed in the cordless base station; "01"—idle, initialization allowed; "10"—ringing; and "11"—conversation. The 2 bit Order field conveys the following: "00"—extended order and "01"—channel change or handoff. The Order Qualifier field of the order message word is defined as: "00000"—overhead and "00001"—send called address. The two synchronization fields employed in the preferred embodiment are: SYNCA="0100 1001 0101 0110 1101" and SYNCB="01 0010 0101 0110 1101". Of course, other synchronization patterns may be used as long as they provide adequate cross correlation properties.

To provide better security and interference protection, the BID with the Order Message word is continuously transmitted subaudibly on the voice channel. The PCC **101** receives and decodes the BID and checks for a match between the subaudibly transmitted BID and the BID of its associated cordless base station **115**. So long as the BIDs match, the conversation on the voice channel may continue. Upon detection of a mismatch, the PCC **101** received audio is muted and the PCC transmitter **403** is unkeyed. After a predetermined period of improper BID reception by the PCC **101** and a subsequent lack of received transmission from the PCC **101** to the cordless base station **115**, the call is terminated.

Given that the priority established for the PCC **101** is that the cordless base station **115** is the first desired path for a user's telephone call and the conventional cellular (or the microcell system) is the second choice, the process of implementing that priority is shown in FIG. **10**. The depiction in FIG. **10** is of the PCC receivers **401** reception of the outbound signalling channel or set of signalling channels transmitted from the cellular system, the cordless base, and the microcellular system relative to time. This diagram aids in the understanding of the unique scanning priority feature of the present invention.

The PCC receiver **401** can be monitoring **1001** the outbound message stream being transmitted from the cellular system signalling channel (which was selected from among the plurality of cellular signalling channels in conventional fashion). At the appropriate time, the PCC receiver **401** is instructed by its microprocessor **409** to tune to the frequency or one of the frequencies being used by the cordless base station **115** as a signalling channel. The PCC receiver **401** scans **1003** the cordless base outbound signalling channel or channels for a period of time t_2. If the signalling data stream is not received with sufficient quality, the PCC receiver **401** is retuned to the previously selected signalling channel of the cellular system **103**. It remains tuned to this signalling channel **1005** for a period of time, t_1, before attempting another scan of a signalling channel of one of the alternative systems. The relationship of t_1 and t_2 is such that a cellular page message (that is, a radiotelephone call or other transmitted requirement) which is repeated, conventionally, after a 5 second pause will not be missed because the PCC receiver **401** was scanning an alternative system during both cellular page message transmission times. The time t_2 must be greater than the sum of the pause between the two pages and the typical time to transmit two pages. The time t_2 must be less than the time between the two pages. If the pause time is 5 seconds and the typical time to transmit a page is 185.2 milliseconds, t_1 must be greater than the 5.3704 seconds and t_2 must be less than 5 seconds. After monitoring the cellular system signalling channel for a time t_1, the PCC receiver **401** may be instructed to tune to the signalling channel or to the signalling channels, sequentially, of the

microcell system, as shown at **1007**. If an adequate microcell signalling channel is not found during the scan of predetermined signalling channel frequencies, the PCC receiver **401** retunes to the cellular system signalling channel, as shown at **1009**.

A scan to the signalling channels, **1011**, of the cordless base station **115** which discovers a signalling data stream meeting appropriate quality requirements results in the PCC receiver **401** continuing to monitor the cordless signalling channel. The PCC receiver **401** remains on the cordless signalling channel without rescanning to another system until the PCC **101** cannot receive the cordless base's transmitted signal for a continuous 5 second period of time.

The effect of this priority process is to give priority to the cordless base station **115** at the PCC **101**. Once the signalling channel of the cordless base station **115** is discovered, the PCC **101** remains tuned to this channel. Thus, when the PCC **101** is initially tuned to the cellular system it will automatically switch to the cordless base station when it is possible to access the cordless base station. Once the PCC receiver **401** has found the cordless base signalling channel, it remains tuned to that channel. When the PCC transceiver is first turned on, its first scan of signalling channels is the preestablished signalling channel or channels of the cordless base station **115**. Of course, the user may override the automatic priority scanning hierarchy by entering an override code into the PCC **101**. In this manner, the user may force the scanning of the cellular system signalling channels only, the cordless base signalling channels only, the microcellular system signalling channels only, or combinations of the systems. The user may also perform a call origination with a one time override to the system of his choice.

Once the signalling channel of a system is being monitored, a visual indication is given to the PCC transceiver user. In the preferred embodiment, this indicator is a set of light emitting diodes (LEDs) **415**, **417**, one of which uniquely illuminates to indicate to which system the PCC transceiver is tuned. Other indicators may alternately be used to convey the same information. For example, a system identifier may appear in the number display of the PCC **101**, or a flashing symbol (having different rates of flashing) may be used. Nevertheless, this indication enables the user to determine which system he is in and decide whether he wishes to complete a radiotelephone call in the indicated system.

Turning now to FIGS. **11-1**, **11-2** and **11-3**, the process followed by the PCC **101** in realizing the scan priority is shown in a flow diagram. This process is executed by the microprocessor **409** from its operating program stored in ROM memory **421**. Upon power-on, at **1101**, the radio sets the cellular scan counter to 0. This variable is utilized to ensure that excessive word synchronization losses or other reasons for excessive cellular rescans do not prevent the PCC **101** from scanning for the cordless base station **115** channels. After resetting the cellular scan counter, the predetermined signalling channel (or channels) of the cordless base station **115** is scanned at **1103** to determine if the PCC **101** is within range of a cordless base station, whether the signalling channel received has the proper BID, and potentially whether the signalling channel has sufficient signal quality. The PCC **101** decides if all the criteria have been met at **1105**. If the criteria have been met, the cordless mode of operation is entered and the user is notified by illumination of the LED associated with the cordless mode, at **1107**. The PCC transceiver remains in the mode of processing cordless functions, at **1109**, including monitoring the cordless base signalling channel, making and receiving radiotelephone calls, and effecting channel change (handoff) between itself and the cordless base, until synchronization or BID is lost between the PCC **101** transceiver and the cordless base station **115** (as detected at **1111**).

If synchronization or BID match becomes lost, the process moves to a check of whether the PCC **101** was engaged in a radiotelephone call, at **1113**. If the PCC **101** were not in a call, the process moves into a scan of the cellular system signalling channels; if the PCC **101** were engaged in a call, several attempts are made to reengage the call in the cordless mode. The cordless base scan counter is reset at **1115** and is checked at **1117** to determine if the counter has gone beyond the maximum number of cordless base scans (maximum=2 in the preferred embodiment). The cordless channels are scanned at **1119** as described for **1103** and the results are checked at **1121**. If the signalling channel from the cordless base station **115** is found, the cordless phone call is resumed. Otherwise, the cordless base scan counter is incremented at **1123** and is rechecked for exceeding the maximum at **1117**. If the cordless base scan counter exceeds the maximum, the PCC **101** will abort the cordless mode and will attempt to scan the signalling channels of the cellular system **103**.

The cellular scan is begun with process **1125** which is also entered from test **1105**. First, the cordless base rescan timer is reset (set to zero) at **1125** to mark the time of the end of the last cordless communication. The cellular scan counter is incremented (1 is added) at **1127** since a cellular scan is about to begin. The PCC **101** scans the cellular system signalling channels, at **1129**, according to conventional user settings.

A test is performed at **1131** to determine if an adequate signalling channel is present in the list of cellular signalling channel frequencies scanned by the PCC **101**. If no channel is acceptable, a "no svc" LED is illuminated, at **1133**, and the process returns to scan the cordless signalling channels at **1101**. If a cellular system signalling channel is found to be acceptable, a LED indicating an in service mode is illuminated and all other service provider LED's are extinguished, at **1135**. The cellular rescan timer is reset at **1137** to determine the time at which the last cellular rescan was completed. The process then progresses to the modified cellular system "idle task", **1138**.

The idle task, **1138**, first determines if it is time for a forced cordless rescan at **1139**. A forced cordless rescan occurs if the cordless base rescan timer is greater than CBRT. CBRT is the cordless base rescan timeout and is set to 60 seconds in the preferred embodiment. In order for the forced cordless rescan to occur, the cellular scan counter must exceed the maximum number of consecutive cellular scans which is set to 6 in the preferred embodiment. The forcing of the rescan is done since the PCC **101** could get stuck in an endless loop if the check were not there and the radio continuously acquired the cellular channel and lost word synchronization. If the forced cordless rescan is not necessary, the PCC **101** goes to the test at **1141** to determine if cellular word synchronization is present. If word synchronization is not present, the PCC **101** rescans the cellular system by starting at **1127**. The resetting of the cordless base rescan timer at **1125** is skipped since the cordless base was not scanned.

If word synchronization is present, a determination of whether a system access is necessary (that is, a call origination, a call page response, or other directed cellular system access) is made at **1143**. If a system access is necessary an attempt is made to conventionally access the cellular system at **1146**. A successful access results in a post

power on return to the process. An unsuccessful access, such as a reception of a page request but an unsuccessful attempt to respond, as determined at **1148**, results in a return to the cellular system signalling channel scan.

If a system access was not deemed necessary at **1143**, a test is performed at **1145** to determine if a cellular rescan should occur. A cellular rescan occurs if the cellular rescan timer exceeds 300 seconds and the cordless rescan timer exceeds the minimum rescan time. The minimum rescan time is the minimum value of t_1 which was 5.3704 seconds in the earlier example. Performing the test of the cordless rescan timer ensures that the PCC **101** has a chance to receive one of the two potential transmissions of the same page. When a cellular rescan occurs, the PCC **101** goes to **1127** thus skipping the resetting of the cordless base rescan timer at **1125**.

If the cellular rescan is not necessary, a test is performed at **1147** to determine if a cordless base rescan should occur. A cordless base rescan occurs if the cordless base rescan timer exceeds CBRT and the cellular rescan timer is greater than the minimum rescan time. The minimum rescan time is 5.3704 seconds. Performing the test of the cellular rescan timer ensures that the PCC **101** has a chance to receive one of the two potential transmissions of the same page. The value of CBRT (cordless base rescan timer) must be greater than t_1 which is 5.3704 seconds. A value of 60 seconds is picked for CBRT for the preferred embodiment. If a cordless base rescan is not necessary, the process starts back at the beginning of the idle task, **1138**. This is the test at **1139**.

If a cordless rescan is necessary, the process begins by resetting the cellular scan counter at **1149**. This is also the first state of a forced cellular rescan which is decided at **1139**. The cellular scan counter is reset at **1149** to assure that a forced cordless scan is not needlessly decided upon at **1139**. After the resetting of the cellular scan counter, the signalling channels of the cordless base station **115** are scanned at **1151** as described for **1103**. If the test at **1153** determines that the base was found, the cordless mode is entered and the user is notified at **1107**. If the cordless base was not found, the PCC **101** must return to the previous control channel at **1155**. It then delays to acquire word synchronization at **1157**. The cordless base rescan timer is reset at **1159** to indicate the time that the last cordless base rescan occurred. Finally, the process resumes at the top of the idle task, **1138**, at test **1139**.

We claim:

1. A method for alternative system selection in which a radiotelephone apparatus which transmits and receives messages on a first radiotelephone system having a first radio coverage area operating in a first frequency band and which alternatively transmits and receives messages on a second radiotelephone system having a second radio coverage area operating in a second frequency band, said first frequency band being a subset of said second frequency band, the method comprising the steps of:

detecting the first radiotelephone system from a subaudible signal transmitted on a radio channel associated with the first radiotelephone system, the step of detecting further comprising the steps of:

receiving the subaudible signal as a message word having a plurality of fields,

decoding the message word, and

comparing identification information contained in one of the plurality of fields to prestored identification information;

monitoring for a predetermined period of time a radio channel associated with the second radiotelephone system when said subaudible signal is not detected;

initiating a telephone call via the first radiotelephone system when said subaudible signal is detected; and

terminating said telephone call when said subaudible signal ceases to be detected.

2. A method for alternative system selection in which a radiotelephone apparatus which transmits and receives messages on a first radiotelephone system having a first radio coverage area operating in a first frequency band and which alternatively transmits and receives messages on a second radiotelephone system having a second radio coverage area operating in a second frequency band, said first frequency band being a subset of said second frequency band, the method comprising the steps of:

detecting the first radiotelephone system from a subaudible signal transmitted on a radio channel associated with the first radiotelephone system, the step of detecting further comprising the steps of:

receiving the subaudible signal as a message word having a plurality of fields,

decoding the message word, and

comparing identification information contained in one of the plurality of fields to prestored identification information;

monitoring for a predetermined period of time a radio channel associated with the second radiotelephone system when said subaudible signal is not detected;

initiating a telephone call via the first radiotelephone system when said subaudible signal is detected; and

muting the audio of said telephone call when said subaudible signal ceases to be detected.

* * * * *

US005684861A

United States Patent [19]

Lewis et al.

[11] Patent Number: 5,684,861

[45] Date of Patent: Nov. 4, 1997

[54] **APPARATUS AND METHOD FOR MONITORING CELLULAR TELEPHONE USAGE**

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[21] Appl. No.: **566,786**

[22] Filed: **Dec. 4, 1995**

[51] **Int. Cl.**[6] **H04M 11/00**; H04M 15/00

[52] **U.S. Cl.** **379/59**; 379/58; 379/114

[58] **Field of Search** 379/59, 58, 62, 379/111–115, 130–133, 144; 455/33.1

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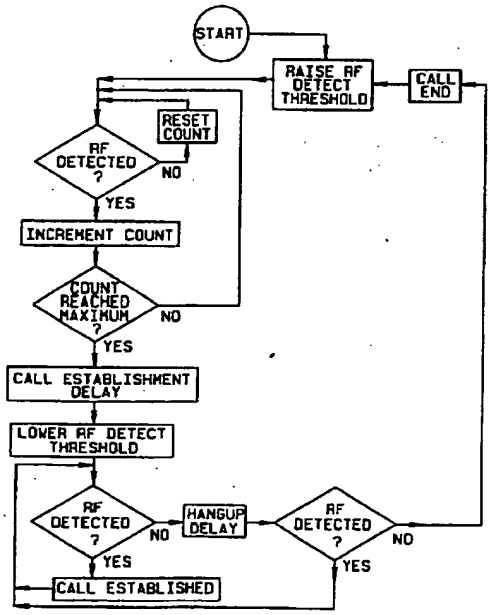
Primary Examiner—Dwayne Bost
Assistant Examiner—Tracy M. Legree
Attorney, Agent, or Firm—Polster, Lieder, Woodruff & Lucchesi

[57] **ABSTRACT**

A small, wireless, battery operated monitoring apparatus is provided that is installed by a user on a cellular telephone in close proximity to a telephone antenna. The monitoring device monitors telephone usage by detecting and tracking radio frequency signal transmissions from the antenna to a base station. The monitoring device includes a microprocessor that performs functions on data indicative of cellular telephone usage and the customer billing plan. The microprocessor, under control of a call processing program, determines exactly when cellular mobile service is established and terminated at the cellular telephone. Under control of a time tracking program, the microprocessor monitors telephone usage, and generates statistical information indicative of telephone usage. The tracking program allows the user to set parameter values associated with statistical information indicative of a customer billing plan and the current date and time. The microprocessor maintains and updates the statistical information, as necessary. The current parameter values for the statistical information generated by the microprocessor are selectively displayed on a display unit associated with the monitoring device. The monitoring device can be used with any manufacturer's cellular telephone, and works with any cellular telephone system standard in the United States or abroad. An alternative embodiment of the present invention allows for the monitoring device to be incorporated into the standard electrical circuitry associated with a cellular telephone such that at least a portion of the monitoring apparatus is contained within the housing of the mobile unit. A method for monitoring telephone usage is also disclosed.

37 Claims, 3 Drawing Sheets



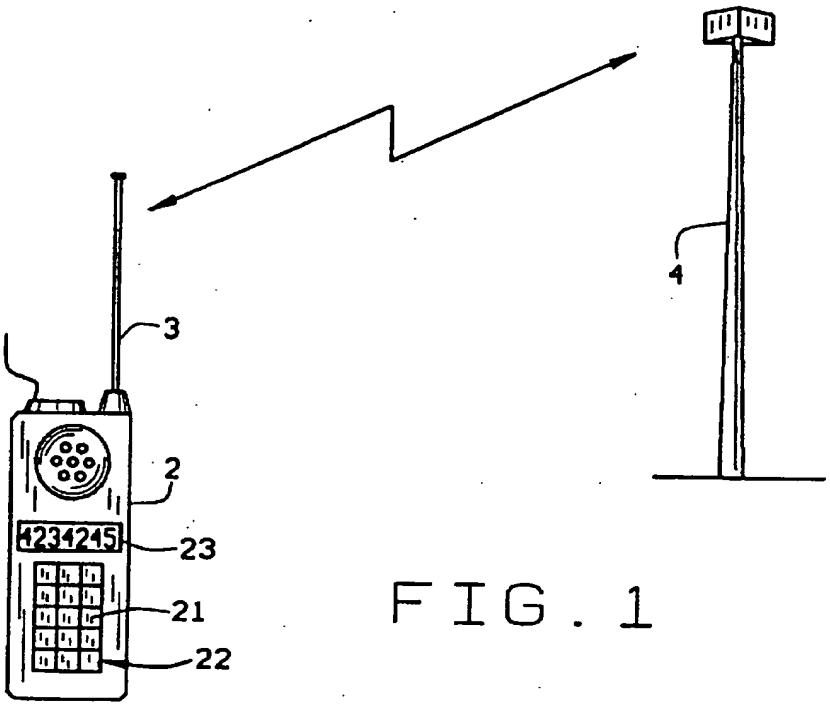

4
3
2
4234245
23
21
22

FIG. 1

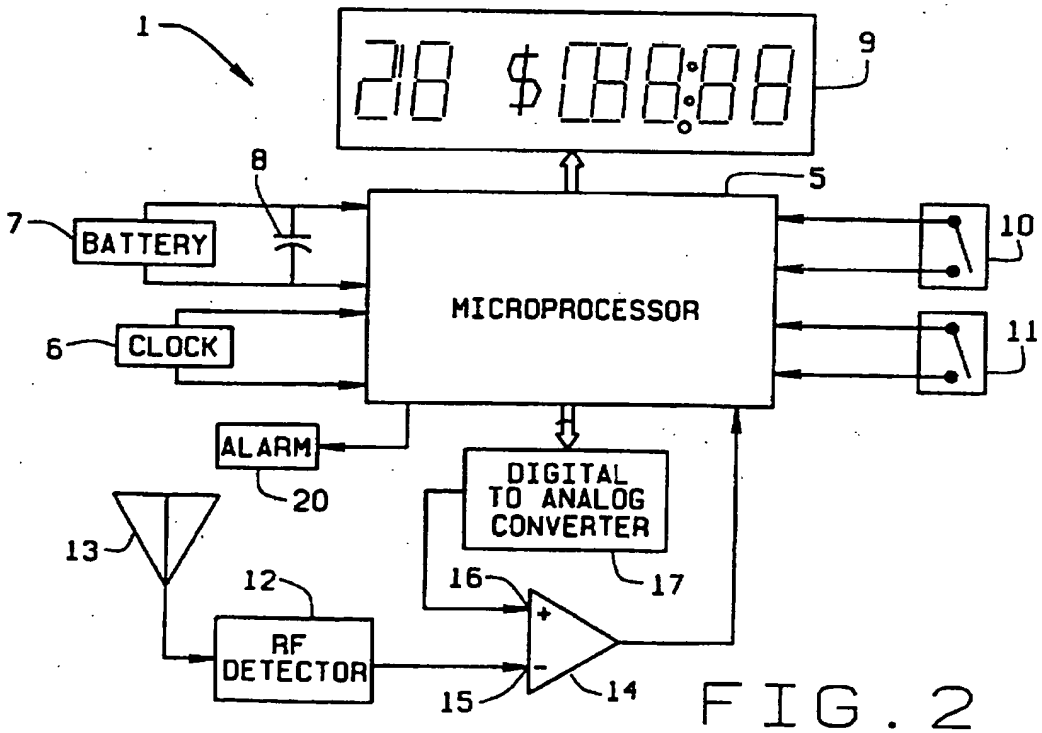

1
28 $ 88:88
9
8
5
7
BATTERY
MICROPROCESSOR
10
6
CLOCK
11
ALARM
20
DIGITAL TO ANALOG CONVERTER
17
13
12
16
RF DETECTOR
15
14

FIG. 2

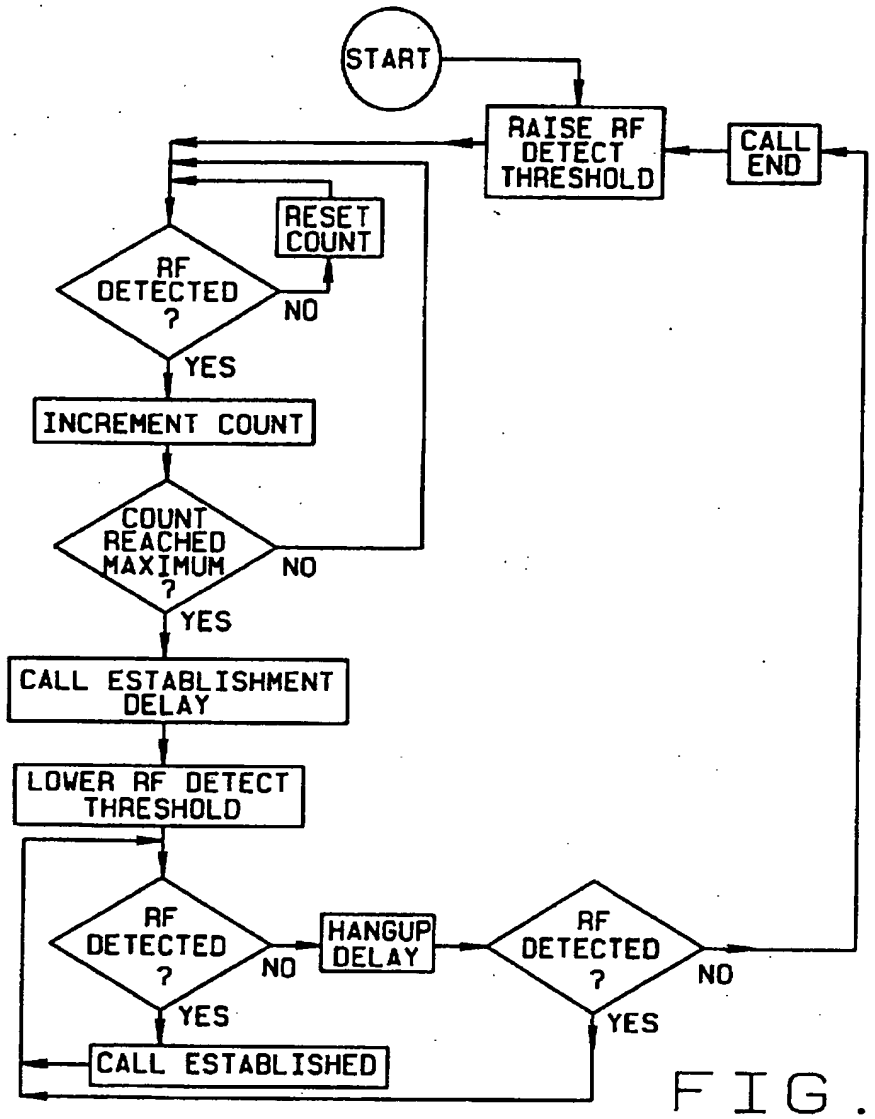

START
RAISE RF DETECT THRESHOLD
CALL END
RESET COUNT
RF DETECTED ?
NO
YES
INCREMENT COUNT
COUNT REACHED MAXIMUM ?
NO
YES
CALL ESTABLISHMENT DELAY
LOWER RF DETECT THRESHOLD
RF DETECTED ?
NO
HANGUP DELAY
RF DETECTED ?
NO
YES
YES
CALL ESTABLISHED

FIG. 3

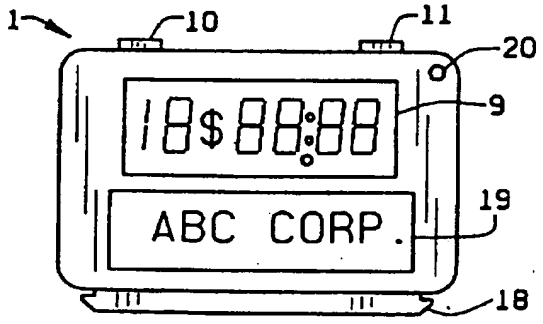

1
10
11
20
18$88:88
9
ABC CORP.
19
18

FIG. 5

FUNCTION CODES	STATISTICAL INFORMATION	FUNCTION DESCRIPTION
P	12:59	DISPLAY PEAK TIME USED OR FREE TIME REMAINING
0	12:59	DISPLAY OFF-PEAK TIME USED OR FREE TIME REMAINING
1	$19999	DISPLAY COST (PEAK+OFF PEAK+CONNECT TIME) FOR CURRENT BILLING PERIOD
2	$19999	DISPLAY ESTIMATED BILL FOR ENTIRE BILLING PERIOD
3	12:59	DISPLAY PEAK TIME USED DURING LAST BILLING PERIOD
4	12:59	DISPLAY OFF-PEAK TIME USED DURING LAST BILLING PERIOD
5	$19999	DISPLAY TOTAL COST FOR LAST BILLING PERIOD
6	12:59 A/P	SET/DISPLAY CURRENT TIME
7	12 31	SET/DISPLAY CURRENT MONTH, DAY OF MONTH
8	SU 7	SET/DISPLAY CURRENT DAY OF WEEK (MO...SU) AND NUMERIC CODE (1...7)
9	1995	SET/DISPLAY CURRENT YEAR
10	SU 7	SET/DISPLAY PEAK START DAY (MO...SU) AND NUMERIC CODE (1...7)
11	SU 7	SET/DISPLAY PEAK END DAY (MO...SU) AND NUMERIC CODE (1...7)
12	12:59 A/P	SET/DISPLAY PEAK START TIME
13	12:59 A/P	SET/DISPLAY PEAK END TIME
14	$199.99	SET/DISPLAY PEAK RATE (CURRENCY PER MINUTE)
15	$199.99	SET/DISPLAY OFF-PEAK RATE (CURRENCY PER MINUTE)
16	$199.99	SET/DISPLAY CONNECT TIME RATE (CURRENCY PER MINUTE)
17	12:59	SET/DISPLAY FREE PEAK HOURS/MINUTES
18	12:59	SET/DISPLAY FREE OFF-PEAK HOURS/MINUTES
19	31	SET/DISPLAY START BILLING DAY OF MONTH
20	2	SET/DISPLAY CELLULAR SYSTEM TAPE
21	9999	SET LOCK-OUT CODE

FIG. 4

APPARATUS AND METHOD FOR MONITORING CELLULAR TELEPHONE USAGE

BACKGROUND OF THE INVENTION

This invention relates generally to wireless communications systems and, more specifically, to a method and apparatus for monitoring and displaying current and cumulative usage data for cellular mobile telephone service provided during a billing period.

The use of cellular telephones has increased dramatically over the last few years. Subscribers to cellular telephone service generally are billed for the time the telephone is in use. Novel or creative billing packages are employed by the cellular service providers as marketing tools.

Often the billing packages include a combination of rates. For example, the service may offer unlimited free off-peak time, limited free off-peak, reduced rates for different times of the day, graduated rates based upon volume usage and so forth. It will be appreciated that regardless of the billing package employed, the telephone user has a keen interest in tracking the amount of time the telephone is in use, for obvious reasons.

Most cellular telephones have a simple built-in timer that indicates the duration of the last call or the total usage since the timer was last reset. These simple timers are of little utility to the user who wishes to track his or her monthly peak or off-peak usage. The user may want to track the total number of peak minutes used in a given billing period. Likewise, the user may want to track the usage in terms of total dollars rather than minutes of air time. With primitive timers, the user may receive an unexpectedly large bill at the end of the month.

The user also may want to track the remaining balance of free minutes. For example, the user may forego using the telephone at certain times of the day for fear of going over budget when, in reality, the user still has unused free or reduced rate time available in the billing period.

In other applications, the owner of the cellular telephone may want to bill a third party for use of the telephone. For example, if the telephone is rented on a short term basis or mounted in a rental car the owner of the telephone would benefit from a quick and accurate readout of total time the phone was in use or total charges incurred by the use of the phone. U.S. Pat. No. 5,233,642, to Renton, describes a device for this type of application. Although the device provides details of each call, it suffers from a number of drawbacks. First, it only operates with its own specific built-in cellular transceiver. It is not interchangeable between phones. It cannot be attached to and transported along with a portable phone. Furthermore, it requires an outside power source and is wired to the cellular transceiver. The Renton device does not display statistical usage information to the user and cannot report actual dollar usage.

There are more than one dozen types of cellular telephone systems in use worldwide. These systems operate at various radio frequencies. For example, these systems include the AMPS (Advanced Mobile Phone Service) system in use in the United States, Canada, Australia and elsewhere. The AMPS system uses mobile to base station frequencies of 825 to 845 MHz. The TACS (Total Access Coverage Service) system is used in the United Kingdom, United Arab Emirates, China and elsewhere and employs mobile to base station frequencies of 890 to 915 MHz. The NMT-450 (Nordic Mobile Telephone) system is in use in France, Switzerland, Saudi Arabia and elsewhere and uses mobile to base station frequencies of 453 to 457.5 MHz. It would be a great advantage to have a device that monitors telephone usage at these various frequencies.

Most cellular telephone systems are analog in nature. The voice signal is modulated directly onto a continuous RF carrier. A single subscriber uses each RF channel for the duration of the telephone call. There are, however, emerging digital cellular standards in which the voice signal is first digitized then transmitted in digital form on an RF carrier which is discontinuous, i.e., the carrier is turned on only periodically, occupying a short time slice which has been dynamically assigned. Such systems include IS-54-B, a digital cellular standard, currently in limited use in the United States, and which transmits discontinuously with a 33.3% duty cycle. IS-95-A, a digital standard, is to be implemented in the United States in 1996 and transmits discontinuously with a 12.5% duty cycle. Finally, GSM, a digital standard, currently in use in Europe, transmits discontinuously with a 12.5% duty cycle. Any device that would monitor cellular phone usage should be able to monitor analog and digital telephone systems.

Furthermore, it will be appreciated that all cellular telephone systems automatically adjust their RF power levels as required by local conditions. Any device used to monitor cellular phone usage should be able to dynamically adjust its input sensitivity. The ability to adjust its input sensitivity would allow the device to ignore unwanted nearby RF signal sources by adjusting to the level of sensitivity needed under the conditions. The lowest power level necessary for telephone call detection under any of the cellular telephone systems is –22 dBm (6.3 milliwatts).

In summary, no device is presently available that is wireless or built directly into a cellular telephone for monitoring cellular telephone usage that can monitor peak, off-peak and connect time or which can display usage in terms of dollars, minutes of peak or off-peak time used or remaining. There is no device that can keep track of totals for a user's monthly billing period or save information from a previous month's use or bill. Furthermore, there is no device available that can be used with any cellular phone, that can adjust its RF detection sensitivity or can be used with various mobile unit systems.

SUMMARY OF THE INVENTION

Accordingly, it is among the principal objects of the present invention to provide a device for the detailed monitoring and display of cellular telephone usage.

It is another object of the present invention to provide such a device that can report the cellular telephone usage in a number of categories including total connect time, peak time used, off-peak time used, unused peak and off-peak time remaining.

Still another object of the present invention is to provide such a device that stores monthly totals.

Yet another object of the invention is to provide such a device that can employs a broad band antenna and RF detection circuit which allows it to be used with any cellular telephone system.

Another object of the invention is to provide such a device that can be used with analog and digital cellular telephone systems.

A still further object of the invention is to provide such a device that is wireless and can be retrofitted to any cellular telephone transceiver.

Another object of the invention is to provide such a device that is economical to manufacture, incorporates a simple

long-life battery for power, is easy to install and well suited for its intended purposes.

A further object of the invention is to provide a device for detailed monitoring and display of cellular telephone usage that can be incorporated into the standard electrical circuitry associated with a cellular telephone such that at least a portion of the device is contained within the housing of the cellular telephone.

These and other objects will become apparent to those skilled in the art in light of the following disclosure and accompanying drawings.

In accordance with the invention, generally stated, an apparatus is disclosed for monitoring when a cellular telephone is used for mobile cellular communications that includes detection means for detecting the presence of a telephone call from the cellular telephone. A programmable control means tracks the duration and time of day associated with the telephone call. The apparatus also includes means for manually inputting data into the data processing means indicative of terms of a customer billing package and current date and time. The control means maintains and updates the data, and generates statistical information based upon the data and the duration and time of day of the telephone call. Display means is provided for selectively displaying statistical information and a function code representative of a particular function performed by the control means in generating the displayed statistical information. A power source is provided for supplying power to the control means.

Another aspect of the present invention is of a device for monitoring usage of a cellular telephone based upon RF signal transmissions from an antenna associated with the cellular telephone that includes detection means for detecting the presence of RF signal transmissions from the cellular telephone, and generating an output signal representative of transmitted RF signals. Data processing means is operatively connected to the detection means. The data processing means generates a reference signal having a preselected magnitude. The data processing means tracks the duration and timing of the output signal generated by the detection means having a magnitude greater than or equal to the magnitude of the reference signal for a period of time exceeding a predetermined time interval. The data processing means performs input, processing, storage, output and control functions to accomplish a sequence of operations on data stored therein, and to generate statistical information indicative of cellular telephone usage based upon RF signal transmissions from the cellular telephone. Means is provided for manually inputting data into the data processing means. Display means displays one of a plurality of function codes representative of a particular function performed by the data processing means in generating the displayed statistical information and the statistical information associated with the displayed function code. Means is provided for selectively viewing any one of the plurality of function codes and associated statistical information by manually advancing the statistical information and function code displayed on the display means. A power source supplies power to the data processing means.

Still another aspect of the present invention is that of a wireless monitoring device for monitoring when a cellular telephone is used for mobile cellular telephone service. The device includes an RF detection circuit including a broadband antenna coupled to an antenna associated with the cellular telephone for detecting RF signal transmission from the telephone antenna, and generating an analog output voltage proportional to transmitted RF signals. A microprocessor is provided for controlling the operation of the monitoring device and processing data indicative of usage of the cellular telephone. The microprocessor includes call processing means for determining whether the cellular telephone is in use, and time tracking means for monitoring duration and timing of the telephone call. The microprocessor generates a digital output signal that is supplied to a digital to analog (D/A) converter. The D/A converter generates an analog reference voltage that is proportional to the digital output signal generated by the microprocessor having a threshold voltage level at or above which the voltage level of the output voltage generated by the RF detection circuit must be maintained for the monitoring device to consider the cellular telephone to be in use. An analog comparator has a first input coupled to the output voltage generated by the RF detection circuit and a second input coupled to the analog reference signal generated by the D/A converter. The comparator generates a digital output signal having a first state when the first input is less than the second input, and a second state when the first input is greater than or equal to the second input. The output signal generated by the comparator is supplied to the microprocessor. A clock is coupled to the microprocessor for generating a clock pulse to provide for synchronization of functions performed by the microprocessor. A display unit allows for individually displaying a plurality of parameter values stored in the microprocessor corresponding to data processed by the microprocessor. First user actuated switching means is connected to the microprocessor for incrementally varying displayed parameter values. Second user actuated switching means is also connected to the microprocessor for advancing the displayed parameter values to the next parameter value stored in the microprocessor. A power source is provided for supplying power to the microprocessor.

Yet another aspect of the present invention is that of a method for monitoring the duration and timing of RF signal transmissions from a cellular phone during a cellular telephone call, comprising the steps of:

manually setting the current day of the week, day of the month, month and year;

detecting the presence of RF signal transmissions from a cellular telephone;

generating a first signal representative of RF signal transmissions;

generating a variable reference signal having a minimum threshold voltage level;

determining whether the first signal is maintained at a voltage level greater than or equal to the minimum threshold voltage level for a first predetermined time interval;

triggering a second predetermined time interval when the first signal is maintained at the voltage level greater than or equal to the minimum threshold voltage level for the first predetermined time interval;

establishing the presence of a telephone call from the cellular telephone when RF signal transmissions are detected after the expiration of the second time interval;

monitoring the duration and timing of the cellular telephone call;

generating statistical information indicative of usage of the cellular telephone based upon the manually set parameter values and the duration and timing of all telephone calls made from the cellular telephone during a predetermined time interval;

displaying statistical information on a visual display;

triggering a third predetermined time interval when RF signal transmissions are not detected after the expiration of the second time interval;

continuing to monitor the duration and timing of the cellular telephone call when RF signal transmissions are detected after the expiration of the third time interval; and

terminating the telephone call when RF signal transmissions are not detected after the expiration of the third time interval.

Other objects and features will be apparent and in part pointed out hereinafter.

BRIEF DESCRIPTION OF THE DRAWINGS

The objects of the invention are achieved as set forth in the illustrative embodiments shown in the drawings which form a part of the specification.

FIG. 1 is a front plan view of a cellular telephone with a wireless monitoring device of the present invention mounted thereon, the cellular telephone shown in relation to a local cellular base station to illustrate environment;

FIG. 2 is a block diagram illustrating the hardware architecture in the monitoring device of the present invention;

FIG. 3 is a flow diagram illustrating the functions performed by the logic module for RF detection;

FIG. 4 is a list of the display functions of the monitoring device of the present invention; and

FIG. 5 is a top elevational view of the wireless monitoring device of the present invention.

Corresponding reference characters indicate corresponding parts throughout the several views of the drawings.

DESCRIPTION OF THE PREFERRED EMBODIMENT

Referring now to FIG. 1, there is shown a monitoring device, indicated generally at 1, attached to a conventional cellular mobile telephone or mobile unit 2 in close proximity to a cellular telephone antenna 3 associated with the mobile unit 2. The mobile unit 2 communicates by two-way radio with a local cellular base station 4. The monitor 1 detects and monitors radio frequency (RF) transmission from the mobile unit 2 to the base station 4.

FIG. 2 best illustrates the internal electrical circuitry and hardware of monitor 1. Monitor 1 employs a controller or microcontroller which acts as a data processing device by performing a plurality of input, processing, storage, output and control functions to accomplish a sequence of operations on data indicative of cellular telephone usage and the terms of a customer billing plan that is stored in the controller. The controller is preferably a microprocessor 5 operating under programmed control as shown in FIG. 2. Certain microprocessor functions are controlled by either a call processing program or a time tracking program stored in the microprocessor 5. The microprocessor 5, under control of the call processing program, determines exactly when cellular mobile telephone service is established and terminated at the mobile unit 2 (see FIG. 3). Under control of the time tracking program, the microprocessor monitors the telephone usage, and generates statistical information indicative of telephone usage such as total time used or available free of charge during specified time intervals (e.g., peak and off-peak time intervals) in a billing period, and the current total cost for total time used in a billing period based upon billing rates associated with specified time intervals and connection time. The time tracking program also allows the user to set parameter values for statistical information indicative of the terms of a particular billing plan or package to which the user subscribes (e.g., billing rates for different times of a day or week, billing period, connection time rates, amount of peak and off peak time available free of charge in a billing period). The user can also set parameter values for statistical information indicating the current day of the week, day of the month, month, year which the microprocessor 5 updates and maintains. As discussed below in greater detail, FIG. 4 sets forth a list of statistical information that can be generated by the microprocessor time tracking program when a user subscribes to a mobile cellular telephone service having a billing package with separate billing rates for peak time and off-peak time and a set amount of time available free of charge during peak and off-peak time for each billing period. It will be appreciated by those skilled in the art that the time tracking program easily can be altered to accommodate different billing plans having alternative billing schemes.

Synchronization of internal components associated with the microprocessor 5 is controlled by timing pulses generated by a clock 6 including a crystal oscillator. The clock 6 is used to control all internal timings, including the time of day and other calendaring functions. The clock 6 allows the microprocessor 5 to accurately determine the date and time at which a telephone call begins and ends.

At least one button cell battery 7 such as a standard watch battery supplies necessary power to the microprocessor 5, based upon the power requirements of the monitoring device 1. A capacitor 8 connected in parallel with the cell battery 7 functions as an energy storage element so that the microprocessor 5 retains stored statistical information, usage data and parameter settings during battery failure or replacement.

The microprocessor 5 drives a digital display 9 such as a liquid crystal display (LCD) that provides a digital readout of alphanumeric symbols representative of function codes and statistical information associated with various time tracking functions performed by the microprocessor 5. The function codes and statistical information associated with each function code are stored in the microprocessor 5. One function code and its associated statistical information are displayed on the display 9 at all times. As will be discussed in greater detail below, the microprocessor 5 automatically updates the statistical information associated with certain functions, when appropriate. The function code, shown on the left side of the display 9 in FIG. 2, indicates a particular time tracking function performed by the device 1 or a particular parameter setting that is used and maintained by the microprocessor in performing the time tracking functions. The statistical information, shown on the right side of the display 9 in FIG. 2, includes usage information indicative of the current parameter value of cellular telephone usage data associated with the displayed function code. The statistical information also includes information that does not directly reflect telephone usage data, such as the current time of day and the current day of week. This type of statistical information may be used by the microprocessor 5 to determine certain usage information. The monitoring device 1 can be programmed to monitor and display information associated with the use and operation of the mobile unit 2. FIG. 4 sets forth a list of possible function codes and statistical information that can be displayed on the digital display 9. FIG. 4 also includes a brief description of each function corresponding to a particular function code which will be discussed more fully below.

The monitoring device 1 also includes two manually operable push button switches, namely, a function switch 10

and a parameter value switch 11. Each switch 10, 11 has a normally open position and an actuated or closed position. The microprocessor 5 periodically examines the position of the switches 10, 11. When the function switch 10 is actuated, the microprocessor 5 changes or advances the displayed function code to the next function code stored in the microprocessor 5. Actuation of the parameter value switch 11 causes the microprocessor 5 to change (e.g., incrementally increase or decrease) the parameter value of the statistical information symbols shown on the display 9, when appropriate if the value is changeable. This allows the user to update the statistical information associated with various functions, e.g., changing the start date, changing the billing rate for peak or off-peak time or changing the current time.

The microprocessor 5 is responsive to RF signals transmitted from the telephone 2 to the cellular base station 4 via the antenna 3 associated with the mobile unit 2. The monitoring device 1 includes an RF detection circuit 12 having a broadband antenna 13 that is effectively coupled to the telephone antenna 3 to detect the presence of RF signal transmissions from the antenna 3. The detection circuit 12 is capable of detecting continuous or periodic RF signal transmissions so as to allow the monitoring device 1 to operate in conjunction with either analog or digital cellular telephones. The broadband antenna 13 has a compact design so that it is easily contained within the packaging (as shown in FIG. 5) of the monitoring device 1. The RF detection sensitivity is adjusted to the appropriate level needed under current conditions, thus allowing the monitor 1 to ignore unwanted nearby RF signal sources. When RF signal transmissions are detected by the antenna 13, the antenna 13 generates a RF signal proportional to the transmitted signal. The detection circuit 12 converts the RF signal to an analog voltage proportional to the RF signal level. In the preferred embodiment, the RF detection circuit 12 is capable of sensing the RF signals having power levels of −22 dBm (6.3 mW). The analog output signal of the RF detector 12 is presented to a first input 15 of an analog comparator 14.

A second input 16 of comparator 14 is operatively connected to the microprocessor 5 via a digital to analog (D/A) converter 17. More specifically, the microprocessor 5 controls RF signal detection sensitivity by generating a digital output signal that is supplied to the D/A converter 17. The D/A converter 17 generates an analog reference signal that is proportional to the digital output signal. The analog reference signal has a minimum threshold voltage level at or above which the output signal of the RF detection circuit 12 must be maintained before the microprocessor 5 performs any time tracking functions monitoring cellular telephone usage. The microprocessor 5 effectively adjusts the minimum threshold voltage level of the analog reference signal by varying its digital output signal, depending upon the type of cellular system employed and the timing of the call processing program and associated functions. The analog reference signal generated by the D/A converter 17 is then presented to the second input 16 of the comparator 14. The comparator 14 generates a binary output signal having a first state or voltage level and a second state or voltage level that is presented to the microprocessor 5.

The output signal of the comparator 14 is maintained in the first state when the voltage level of the output signal generated by the RF detection circuit 12 is less than the minimum threshold voltage level of the reference signal. In this situation, the mobile unit 2 is not in use and time tracking functions associated with the microprocessor are deactivated. When the voltage level of the RF signal is greater than or equal to the minimum threshold level, the output signal of the comparator 14 changes state so as to be maintained in the second state. As will be discussed in greater detail below with respect to FIG. 3, when the output signal is maintained in the second state for a predetermined time interval (call establishment delay period), the microprocessor 5, under the control of the call processing program, activates the time tracking program to monitor the time the mobile unit is in use. The time tracking program remain activated by the microprocessor 5 until the output signal of the comparator 14 changes to the first state for a predetermined time interval (hang-up delay period).

The call processing program for microprocessor 5 used in a TIA-553 (U.S. analog) cellular system is set forth in the flow chart shown in FIG. 3. The call processing program is activated immediately after the microprocessor 5 is reset when the cellular telephone 2 is turned on. The microprocessor 5, under the control of the call processing program, first increases the RF detection threshold level. The microprocessor 5 is programmed to periodically check the state of the RF detector 12 to determine whether an RF signal is being transmitted from the mobile unit 2. The microprocessor 5 then counts how many times the call processing program has detected the presence of an RF signal. If a predetermined maximum number of RF signals is detected, then a reliable RF signal is present, indicating the cellular telephone 2 is being used for mobile cellular telephone service.

The RF signal transmission from the mobile unit 2 requesting service and identifying the mobile unit 2 when power is turned on is known as a service request. Once the service request is transmitted from the mobile unit 2, the mobile unit 2 turns off its carrier frequency and goes into an await message mode, waiting on a reply from the base station 4. The cellular monitor then initiates a predetermined delay period referred to as a call establishment delay, which extends for the maximum time it might take the cellular base station to respond by assigning the initial frequencies to be used for signal transmission and reception, plus the time it takes for approximately four ringing tones to be emitted from the mobile unit 2. The time delay associated with the four ringing tones allows the mobile user time to hang up the phone before registering any time with the monitoring device 1. Beyond four rings, air time is typically charged to the cellular customer.

At the expiration of the call establishment delay, the microprocessor 5 lowers the RF detection threshold level. If the user hangs up prior to the expiration of the call establishment delay, then the RF signal is no longer detected by the RF detection circuit 12, and the call processing program activates a hang-up delay period which will be discussed below in greater detail. If the call goes through, the RF signal having a magnitude greater than or equal to the threshold level is detected by the RF detector 12 after the expiration of the call establishment delay such that the beginning of a call is established, and the monitoring device 1 begins tracking the time associated with the call by activating the time tracking program.

If the RF detector 12 fails to detect the presence of RF signal transmission after the expiration of the call delay or after a call is established, the microprocessor activates a hang-up delay period. The hang-up delay corresponds to a predetermined time interval that prevents premature termination of the time tracking functions associated with the microprocessor 5 by allowing for potential noise hits which may cause momentary losses of RF detection. If RF signal transmission is detected after the expiration of the hang-up delay, the microprocessor 5 continues monitoring the dura-

tion and timing of signal transmissions pursuant to the time tracking functions. If RF signal transmissions are not detected after the expiration of the hang-up delay period, the call ends and service is terminated to the mobile unit 2. The RF detection threshold level is then raised, and call processing begins again.

The cellular monitoring device 1, under the control of the time tracking program, constantly displays a function code and associated statistical information on the digital display 9. FIG. 4 sets forth a possible list of function codes, the format of the statistical information, and function descriptions used for a particular billing plan. Each function code is an alphanumeric character or set of characters that represent a time tracking function performed by the microprocessor 5 under control of the time tracking program. For example, function code "5" can be used to indicate the current time of day (see FIG. 4), or the phrase "TIME OF DAY" may be displayed as the function code. As mentioned above, the time tracking functions performed by the microprocessor 5 monitor the duration and timing of cellular telephone usage, and generate statistical information indicative of the usage of the cellular telephone 2. The function switch 10 allows the user to selectively display one of a plurality of function codes stored in the microprocessor 5, and the current parameter value of the statistical information associated with the displayed function code on the display 9. As mentioned above, when the user presses or actuates the function switch 10, the function code and statistical information displayed on the display 9 advances a different function code and associated statistical information maintained by the microprocessor 5.

Function code "P" or "o" is automatically displayed on the display 9 if the user has not actuated the function switch 10 or the parameter value switch 11 for a certain period of time. The "P" function code and associated statistical information is automatically displayed if the current time of day is within the designated peak period. Likewise, the "o" function code and associated statistical information is automatically displayed if the current time of day is outside the designated peak period (i.e., the off-peak period).

The time tracking function associated with the "P" function code calculates the current peak time used, or if a non-zero value was entered for the statistical information corresponding to function code 16 (Set/display free peak hours/minutes), the microprocessor 5 calculates the number of remaining free minutes. If all remaining free minutes have been consumed, and a non-zero value was entered for the statistical information corresponding to function code 13 (peak rate, cost per minute) then the microprocessor 5 is programmed to calculate total cost. If all remaining free minutes have been consumed, and a zero value was entered for the statistical information corresponding to function code 13 (peak rate, cost per minute) then the microprocessor 5 continues to calculate time, but the microprocessor 5 counts up instead of down, and flashes a visual alarm and/or sounds an audible alarm (referred to collectively as alarm 20). The display 9 shows the current parameter value for the associated statistical information when the "P" function code is displayed.

The microprocessor function associated with the "o" function code operates in a manner similar to the "P" function. The "o" function calculates the current off-peak time used, or if a non-zero value was entered for the statistical information associated with function code 17 (Set/display off-free peak hours/minutes), calculates the number of remaining free minutes. If all remaining free minutes have been consumed, and a non-zero value was entered for the statistical information associated with function code 14 (off-peak rate, cost per minute) then the microprocessor 5 calculates total cost. If all remaining free minutes have been consumed, and a zero value was entered for function 14 (off-peak rate, cost per minute) then the microprocessor 5 continues to calculate time, but counts up instead of down, and flashes the visual alarm and/or sounds the audible alarm 20. The display 9 shows the current parameter value for the statistical information calculated by the microprocessor 5 when the "o" function code is displayed.

The time tracking function associated with function code 1 calculates the current month's total cost to date, which includes peak, off-peak and connect charges. When function code 1 is displayed, the display 9 shows statistical information indicating the current month's total cost. If no rates were entered for peak, off-peak or connect time, then zero is displayed for the parameter value.

When function code 2 is displayed, the display 9 shows statistical information indicating the estimated total cost (bill) for the entire billing period based upon the rate of telephone usage to date.

When function code 3 is displayed, the display 9 shows statistical information indicating last month's total peak time used.

When function code 4 is displayed, the display 9 shows statistical information indicating last months off-peak time used.

When function code 5 is displayed, the display 9 shows statistical information indicating last months total cost, which includes peak, off-peak and connect charges. If no rates were entered for peak, off-peak or connect time, then zero is displayed.

When function code 6 is displayed, the display 9 shows statistical information indicating the current time of day. The user can actuate the parameter value switch 11 to change the current time of day, if desired.

When function code 7 is displayed, the display 9 shows statistical information indicating the current month and day of month. The user can actuate the parameter value switch 11 to change the current month and day, if desired.

When function code 8 is displayed, the display 9 shows statistical information indicating the current day of week (MO, TU, WE, TH, Fr, SA, SU) along with a numeric code (1 . . . 7) indicating the day of the week for the purpose of being foreign language compatible. The user can press the parameter value switch 11 to change the current day of the week and numeric code, if desired.

When function code 9 is displayed, the display 9 shows statistical information indicating the current year. This is used for determining leap years. The user can press the parameter value switch 11 to change the current year, if desired.

When function code 10 is displayed, the display 9 shows statistical information indicating the peak start day (MO, TU, WE, TH, Fr, SA, SU) along with a numeric code (1 . . . 7) indicating the day of the week. The user can actuate the parameter value switch 11 to change the peak start day, if desired.

When function 11 is displayed, the display 9 shows statistical information indicating the peak end day (MO, TU, WE, TH, Fr, SA, SU) along with a numeric code (1 . . . 7) indicating the day of the week. The user can press the parameter value switch 11 to change the peak end day, if desired.

When function code 12 is displayed, the display 9 shows statistical information indicating the peak start time of day. The user can actuate the parameter value switch 11 to change the peak start time, if desired.

When function code 13 is displayed, the display 9 shows statistical information indicating the peak end time of day. The user can actuate the parameter value switch 11 to change the peak end time, if desired.

When function code 14 is displayed, the display 9 shows statistical information indicating the peak rate in dollars and cents (or the corresponding local currency) per minute. The user can press the parameter value switch 11 to change the peak rate, if desired.

When function code 15 is displayed, the display 9 shows statistical information indicating the off-peak rate in dollars and cents (or the corresponding local currency) per minute. The user can press the parameter value switch 11 to change the off-peak rate, if desired.

When function code 16 is displayed, the display 9 shows statistical information indicating the connect time rate in dollars and cents (or the corresponding local currency) per minute. The user can actuate the parameter value switch 11 to change the connect time rate, if desired.

When function code 17 is displayed, the display 9 shows statistical information indicating the number of free peak hours/minutes. The user can press the parameter value switch 11 to change the number of free peak hours/minutes, if desired.

When function code 18 is displayed, the display 9 shows statistical information indicating the free off-peak hours/minutes. The user can press the parameter value switch 11 to change the number of free off-peak hours/minutes, if desired.

When function code 19 is displayed, the display 9 shows statistical information indicating the starting day of the month for the user's billing period. The user can press the parameter value switch 11 to change the starting day of the billing period, if desired.

When function code 20 is displayed, the display 9 shows statistical information indicating the type of cellular telephone system employed. As mentioned in the BACKGROUND OF THE INVENTION section, cellular telephone systems operate within various ranges of radio frequencies and power levels. This feature allows the monitoring device 1 to be used with any of the more than one dozen cellular telephone systems in use worldwide, such as AMPS, TACS, and NMT-450. The user can press the parameter value switch 11 to change the cellular system type, if desired.

The microprocessor function associated with function code 21 allows the user to set a lock-out code which locks out or prevents any changes to any parameters, until the same lock-out code is re-entered by the user. When function code 20 is displayed, the user has the option of changing the lock out code by pressing the parameter value switch 11.

FIG. 5 shows the preferred embodiment of the small, wireless, battery operated monitoring device 1 which can be quickly and easily mounted to the mobile unit 2 by the user. The overall dimensions of the monitor 1 in the preferred embodiment are approximately 1.3"×0.8"×0.4". The compact design of the monitor 1 allows the monitor 1 to fit unobtrusively on the cellular phone 2 near the telephone antenna 3. The monitoring device can be used with any manufacturer's cellular telephone, and works with any cellular telephone system standards in the United States or abroad. The monitor 1 can be attached to the mobile unit 2 in numerous fashions. For example, the monitor 1 can be attached to the mobile unit 2 with a hook and eye type fastener, double-sided sticky foam tape, tamper resistant fixtures or tamper indicators (for use with rental cellular telephones). The user can reference a slide-out card 18 (shown partially in phantom in FIG. 5) which lists the function codes and their corresponding function descriptions. A recessed rectangular area 19 allows for insertion of a logo or advertisement below the display 9. The monitoring device 1 can be employed in conjunction with both analog and digital mobile cellular telephone systems, and is programmable by the user to switch between the various system types (function code 19).

FIG. 5 also depicts the visual alarm 20 such as an LED light source which alerts the user when no time is available free of charge during peak and/or off-peak billing hours. Alternatively, the visual alarm can be incorporated into the display 9 such that an indicator appears on the display when the free time has been consumed. Similarly, the monitoring device can be configured so that the displayed function code and statistical information blink rapidly to provide a visual indication to the user in this situation. As mentioned above, an audible alarm can be provided in addition to or instead of the visual alarm. The audible alarm is driven by the microprocessor 5, and provides an audible warning to the user when no time is available free of charge during peak and/or off peak billing hours.

In an alternate embodiment of our present invention, the monitoring device 1 and associated microprocessor functions are incorporated directly into the mobile unit 2, thus eliminating the need for antenna 13, RF detection circuit 12, comparator 14, and D/A converter 17. In this situation, the microprocessor 5 is disposed within the housing of the cellular telephone, and is preferably representative of the controller or microprocessor typically associated with internal circuitry of the mobile unit. The microprocessor uses the standard detection circuitry associated with the mobile unit to determine when a signal is transmitted from the cellular telephone antenna. The controller or microprocessor of the mobile unit is programmed to perform the call processing functions and time tracking functions set forth above. Manually operable push button keys 21 associated with a key pad 22 of the cellular telephone can be used instead of push button switches 10 and 11 such that the controller or microprocessor is responsive to manual actuation of certain preselected keys 21. A digital display that is visible to the user such as the display 9 discussed above is used to provide a readout of the function codes and statistical information. In this situation, the display 16 can be a display 23 currently used on cellular telephones to display the number dialed. Furthermore, the power source can be a standard rechargeable battery typically associated with cellular telephones, such as a Ni—Cd battery. However, this alternate embodiment of our present invention may not be as desirable to mobile cellular telephone service providers as our wireless embodiment because of the problems associated with programming changes for the controller or microprocessor if the provider changes the billing plan.

The foregoing description is set forth for illustrative purposes only and is not meant to be limiting. Numerous variations, within the scope of the appended claims will be apparent to those skilled in the art in light of the foregoing description and accompanying drawings. For example, the monitoring device 1 can be used in conjunction with a remote antenna and RF detection circuit placed in close proximity to the remote antenna, such as may be the case

with a window mounted antenna. In addition, the microprocessor 5 can be replaced with a random logic design. An audible alarm can be incorporated into the monitoring device to indicate when all free minutes have been consumed. A visual or audible alarm can also be provided for alerting the user when the cell battery needs to be replaced. The preferred embodiment monitors calls made during peak and off-peak hours since standard billing packages associated with mobile cellular phone service typically structure a customer's billing plan based on these usage patterns. However, the microprocessor 5 clearly can be programmed to accommodate alternative billing plans. For example, the monitoring device can track the time and cost associated with a billing plan having four billing rates corresponding to four periods of time for each day or week. Similarly, the monitoring device can monitor only total usage each day if a customer's billing plan does not make any distinctions between peak and off-peak hours.

Having thus described the invention, what is claimed and desired to be secured by Letters Patent is:

1. An apparatus for monitoring when a cellular telephone is used for mobile cellular telephone communication, comprising:

detection means for detecting the presence of a telephone call from the cellular telephone;

programmable control means for tracking the duration and time of day associated with the telephone call wherein said control means is contained within a housing that is manually mounted on a mobile unit in close proximity to an antenna associated with the mobile unit, said detection means detects the presence of RF signals transmissions from the antenna associated with the mobile unit indicative of the telephone call, and said control means tracks the duration and timing of RF signals detected by said detection means that have a magnitude maintained at a level greater than or equal to a minimum threshold level for at least a predetermined time interval;

means for manually inputting data into said control means indicative of terms of a customer billing plan and current date and time, said control means maintaining and updating the data, and generating statistical information based upon the data and the duration and time of day of the telephone call;

a display means for selectively displaying statistical information and a function code representative of a particular function performed by said control means in generating the displayed statistical information; and

a power source for supplying power to said control means.

2. The apparatus as set forth in claim 1 wherein said control means is disposed within a mobile unit housing.

3. The apparatus as set forth in claim 2 wherein said means for manually inputting data corresponds to manually operable push buttons on a key pad associated with the mobile unit.

4. The apparatus as set forth in claim 1 wherein said display means is a liquid crystal display.

5. An apparatus for monitoring usage of a cellular telephone based upon radio frequency (RF) signal transmissions from an antenna associated with the cellular telephone, comprising:

detection means for detecting the presence of RF signal transmissions from the cellular telephone antenna, and generating an output signal representative of transmitted RF signals;

data processing means operatively connected to said detection means, said data processing means generating a reference signal having a preselected magnitude, said data processing means tracking the duration and timing of the output signal generated by said detection means having a magnitude greater than or equal to the magnitude of the reference signal for a period of time exceeding a predetermined time interval, said data processing means performing input, processing, storage, output and control functions to accomplish a sequence of operations on data stored therein, and generating statistical information indicative of cellular telephone usage based upon RF signal transmissions from the cellular telephone;

means for manually inputting data into said data processing means;

display means for displaying one of a plurality of function codes representative of a particular function performed by said data processing means in generating the displayed statistical information and the statistical information associated with the displayed function code;

means for selectively viewing any one of the plurality of function codes and associated statistical information displayed on the display means; and

a power source for supplying power to said data processing means.

6. The monitoring apparatus as set forth in claim 5 further including comparison means for determining whether the output signal of the detection means has a magnitude greater than or equal to the magnitude of the reference signal, said comparison means having a first input receiving the output signal generated by said detection means and a second input receiving the reference signal generated by said data processing means, said comparison means generating an output signal maintained in a first state when the first input is less than the second input and in a second state when the first input is greater than or equal to the second input, the second state of the output signal being representative of the presence of RF signal transmissions associated with mobile cellular telephone service from the cellular phone, the output signal being supplied to the data processing means.

7. The monitoring apparatus as set forth in claim 5 wherein said data processing means generates statistical information indicating current cost associated with cellular telephone usage for a preselected time interval.

8. The monitoring apparatus as set forth in claim 5 wherein said data processing means generates statistical information indicating total time available for RF signal transmissions free of charge in a preselected time interval.

9. The monitoring apparatus as set forth in claim 5 wherein the cellular phone provides analog cellular mobile telephone services.

10. The monitoring apparatus as set forth in claim 5 wherein the cellular phone provides digital cellular mobile telephone services.

11. The monitoring apparatus as set forth in claim 5 wherein said detection means is disposed in close proximity to the antenna associated with the cellular telephone.

12. The monitoring apparatus as set forth in claim 11 wherein said data processing means is located in close proximity to said detection means.

13. The monitoring apparatus as set forth in claim 11 wherein the antenna associated with the cellular telephone is disposed at a remote location in relation to the cellular telephone.

14. The monitoring apparatus as set forth in claim 13 wherein said data processing means is disposed in close proximity to the cellular telephone at a remote location in relation to said detection means.

15. A wireless monitoring device for monitoring when a cellular telephone is used for mobile cellular telephone service, comprising:

a radio frequency (RF) detection circuit including a broadband antenna coupled to an antenna associated with the cellular telephone for detecting RF signal transmission from the cellular telephone antenna, and generating an analog output voltage proportional to transmitted RF signals;

a microprocessor for controlling the operation of said monitoring device and processing data indicative of the usage of the cellular telephone, said microprocessor including call processing means for determining whether the cellular telephone is in use and time tracking means for monitoring duration and timing of the telephone call, said microprocessor generating at least one digital output signal;

a digital to analog (D/A) converter responsive to the digital output signal generated by said microprocessor, said D/A converter generating an analog reference voltage proportional to the digital output signal generated by the microprocessor having a threshold voltage level at or above which the voltage level of the output voltage generated by said RF detection circuit must be maintained for said monitoring device to consider the cellular telephone to be in use;

an analog comparator having a first input coupled to the output voltage generated by said RF detection circuit and a second input coupled to the analog reference signal generated by said D/A converter, said comparator generating a digital output signal maintained in a first state when the first input is less than the second input and maintained in a second state when the first input is greater than or equal to the second input, the output signal generated by the comparator being supplied to said microprocessor;

a clock coupled to said microprocessor for generating a clock pulse to provide for synchronization of functions performed by said microprocessor;

a display unit for individually displaying a plurality of parameter values stored in the microprocessor corresponding to data processed by said microprocessor;

first user actuated switching means connected to said microprocessor for incrementally varying displayed parameter values;

second user actuated switching means connected to said microprocessor for advancing the displayed parameter values to the next parameter value stored in the microprocessor; and

a power source for supplying power to said microprocessor.

16. The monitoring device as set forth in claim 15 wherein said call processing means is responsive to the state of the output signal generated by said analog comparator, said call processing means activating said time tracking means when the output signal is maintained in the second state for a period of time exceeding a first predetermined delay period, said call processing means deactivating the time tracking means when said output signal returns to the first state for a period of time exceeding a second predetermined delay period.

17. The monitoring device as set forth in claim 16 wherein the call processing means increases the minimum threshold level of the reference voltage generated by said microprocessor when the output signal of said comparator is maintained in the second state.

18. The monitoring device as set forth in claim 17 wherein the call processing means determines the number of times the presence of RF signal transmissions is detected by said RF detection circuit, and generates a message signal when a predetermined number of RF signal transmissions is detected.

19. The monitoring device as set forth in claim 18 wherein the call processing means triggers the first delay period after the predetermined number of RF signal transmissions is detected.

20. The monitoring device as set forth in claim 16 wherein the call processing means decreases the minimum threshold level of the reference voltage generated by said microprocessor when the presence of RF signal transmission is detected by the RF detection circuit after the expiration of the first delay period.

21. The monitoring device as set forth in claim 20 wherein the call processing means triggers the second delay period when no RF signal transmission is detected by said RF detection circuit after the expiration of the first delay period.

22. The monitoring device as set forth in claim 21 wherein the call processing means increases the minimum threshold level of the reference voltage generated by said microprocessor when the absence of RF signal transmission is detected by the RF detection circuit for a period of time greater than the second delay period.

23. The monitoring device as set forth in claim 16 wherein the time tracking means determines cumulative connect time the cellular telephone is used for mobile cellular telephone service during a predetermined time interval.

24. The monitoring device as set forth in claim 23 wherein the time tracking means determines cumulative time the cellular telephone is used for mobile cellular telephone service during peak billing hours for the predetermined time interval.

25. The monitoring device as set forth in claim 24 wherein the time tracking means determines cumulative time the cellular telephone is used for mobile cellular telephone service during off-peak billing hours for the predetermined time interval.

26. The monitoring device as set forth in claim 25 wherein the time tracking means determines cumulative cost for the total time the cellular telephone is used for mobile cellular telephone service during peak hours and off-peak hours for the predetermined time interval based upon billing rates associated with connect time, peak time and off-peak time.

27. The monitoring device as set forth in claim 23 wherein the predetermined time interval corresponds to a monthly billing period.

28. The monitoring device as set forth in claim 16 wherein the time tracking means monitors and updates current time of day, day of a week, day of a month, month and year.

29. The monitoring device as set forth in claim 16 wherein the time tracking means determines current total time available for cellular telephone use free of charge during peak billing hours for a predetermined time interval, and determines current total time available for cellular telephone use free of charge during off-peak billing hours for the predetermined time interval.

30. The monitoring device as set forth in claim 29 further including a visual alarm controlled by said microprocessor, said microprocessor activating said alarm when no time is available free of charge during peak billing hours, and when no time is available free of charge during off-peak billing hours.

31. The monitoring device as set forth in claim 29 further including an audible alarm controlled by said

microprocessor, said microprocessor activating said alarm when no time is available free of charge during peak billing hours, and when no time is available free of charge during off-peak billing hours.

32. The monitoring device as set forth in claim 15 further including means for preventing unauthorized variation of displayed parameter values via said first user actuated switching device.

33. The monitoring device as set forth in claim 15 wherein said power source is at least one button cell battery.

34. The monitoring device as set forth in claim 33 further including energy storage means connected in parallel with the battery to provide power to the microprocessor during battery failure and replacement.

35. A method for monitoring the duration and timing of radio frequency (RF) signal transmissions from a cellular phone indicative of the presence of a cellular telephone call, comprising the steps of:

manually setting a plurality of parameter values associated with statistical information indicative of a customer billing plan;

detecting the presence of RF signal transmissions from a cellular telephone antenna;

generating a first signal representative of RF signal transmissions;

generating a variable reference signal having a minimum threshold voltage level;

determining whether the first signal is maintained at a voltage level greater than or equal to the minimum threshold voltage level for a first predetermined time interval;

triggering a second predetermined time interval when the first signal is maintained at the voltage level greater than or equal to the minimum threshold voltage level for the first predetermined time interval;

establishing the presence of a telephone call from the cellular telephone when RF signal transmissions are detected after the expiration of the second time interval;

monitoring the duration and timing of the cellular telephone call;

generating statistical information indicative of usage of the cellular telephone based upon the manually set parameter values and the duration and timing of all telephone calls made from the cellular telephone during a predetermined time interval;

displaying statistical information on a visual display;

triggering a third predetermined time interval when RF signal transmissions are not detected after the expiration of the second time interval;

continuing to monitor the duration and timing of the cellular telephone call when RF signal transmissions are detected after the expiration of the third time interval; and

terminating the telephone call when RF signal transmissions are not detected after the expiration of the third time interval.

36. The method for monitoring a cellular telephone call as set forth in claim 35 wherein the step of manually setting parameter values associated with statistical information indicative of the customer billing plan includes the steps of:

manually setting the current day of the week, day of the month, month and year;

manually setting the current time of day;

manually setting a start date and a stop date for a user-defined billing period;

manually setting a start time of the day and a stop time of the day for a first daily time interval;

manually setting a start day of the week and a stop day of the week for the first time interval;

manually setting a billing rate per minute for mobile cellular telephone service provided during the first time interval;

manually setting the amount of time in the first time interval for which mobile cellular telephone service is available free of charge;

manually setting a start time of the day and a stop time of the day for a second daily time interval;

manually setting a start day of the week and a stop day of the week for the second time interval;

manually setting a billing rate per minute for mobile cellular telephone service provided during the second time interval;

manually setting the amount of time in the second time interval for which mobile cellular telephone service is available free of charge; and

manually setting the billing rate per minute for connection time associated with mobile cellular telephone service provided during the first and second time intervals.

37. The method of monitoring the duration and timing of a cellular telephone call as set forth in claim 35, further including the steps of:

determining the current total time the cellular telephone is in use during the billing period for a first daily time interval having a first billing rate;

determining the current total time the cellular telephone is in use during the billing period for a second daily time interval having a second billing rate;

maintaining calendar information indicating the current day of the week, day of the month, month and year;

tracking the current time of day;

determining the current total cost for total time used in the billing period based upon the first time period at the first billing rate, and the second time period at the second billing rate, and the total connection time at the connection rate;

determining an estimated total cost for the entire billing period based upon the rate of cellular telephone usage to date;

maintaining statistical information indicating total time used during the first time period for the immediately preceding billing period;

maintaining statistical information indicating total time used during the second time period for the immediately preceding billing period; and

maintaining statistical information indicating total costs accrued during the immediately preceding billing period.

* * * * *

US006253088B1

(12) **United States Patent**
Wenk et al.

(10) **Patent No.: US 6,253,088 B1**
(45) **Date of Patent: Jun. 26, 2001**

(54) **PERSONAL BASE STATION FOR INTEGRATED CELLULAR AND CORDLESS COMMUNICATION SYSTEM**

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(73) Assignee: **Uniden America Corporation**, Ft. Worth, TX (US)

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 0 days.

(21) Appl. No.: **08/977,009**

(22) Filed: **Nov. 24, 1997**

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(52) **U.S. Cl.** **455/462**; 455/426; 455/561; 455/463; 455/417; 455/465; 455/461; 455/435; 455/433

(58) **Field of Search** ..... 455/462, 426, 455/414, 465, 561, 550, 552, 403, 463, 435, 433, 461, 417; 379/106 FOR, 428, 433

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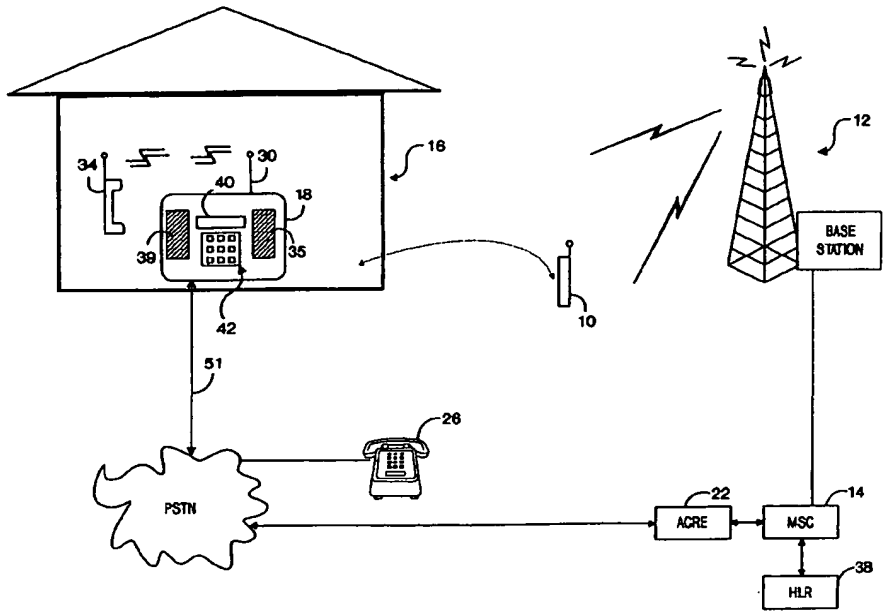
Primary Examiner—William G. Trost
Assistant Examiner—Keith Ferguson
(74) *Attorney, Agent, or Firm*—Kevin J. Zimmer; Cooley Godward LLP

(57) **ABSTRACT**

An integrated cellular and cordless communication system in which cellular calls are forwarded to a landline telephone number associated with a personal base station when a subscriber terminal is determined to be within a predefined vicinity of the personal base station is described herein. Once forwarded to the personal base station via external network elements, such calls may be answered using a cordless device operative to communicate with the personal base station. Alternately, the calls may be transferred to a voice messaging module within the personal base station. When the subscriber terminal is determined to have been removed from within the vicinity of the personal base station, a message from the personal base station to the external network elements results in modification of a call forwarding address such that subsequent calls intended for the subscriber terminal are in fact routed thereto. The personal base station may also be optionally implemented to enable the forwarding of calls intended for the personal base station to the subscriber terminal. A subscriber could indicate the desire for this type of call forwarding by way of, for example, a user interface of the personal base station. In response, the personal base station would issue a request to the external network elements to forward subsequent calls intended for the landline telephone number of the personal base station to the subscriber terminal.

2 Claims, 9 Drawing Sheets



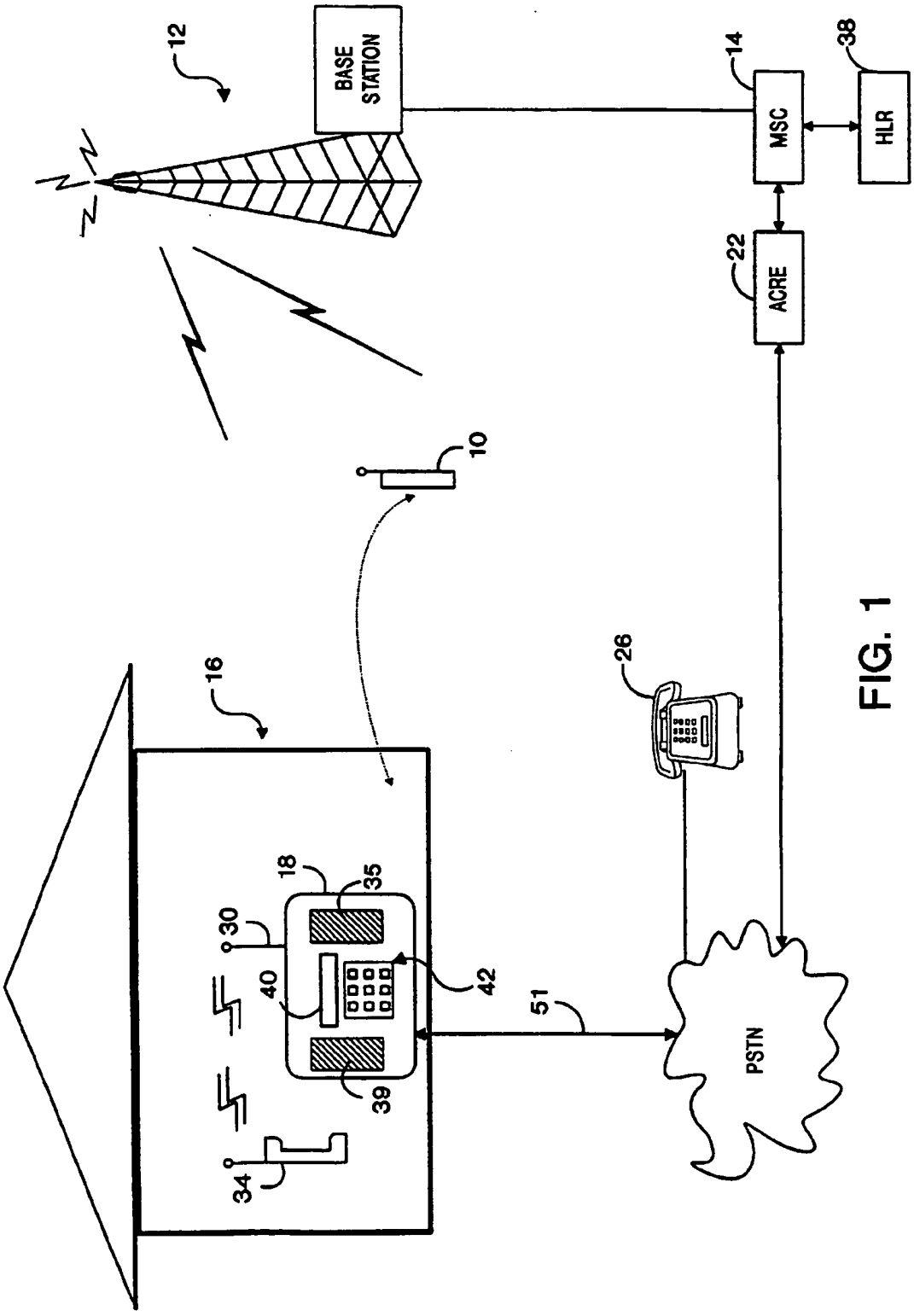

12
BASE STATION
14
MSC
38
HLR
22
ACRE
10
16
26
18
35
30
40
42
51
39
34
PSTN

FIG. 1

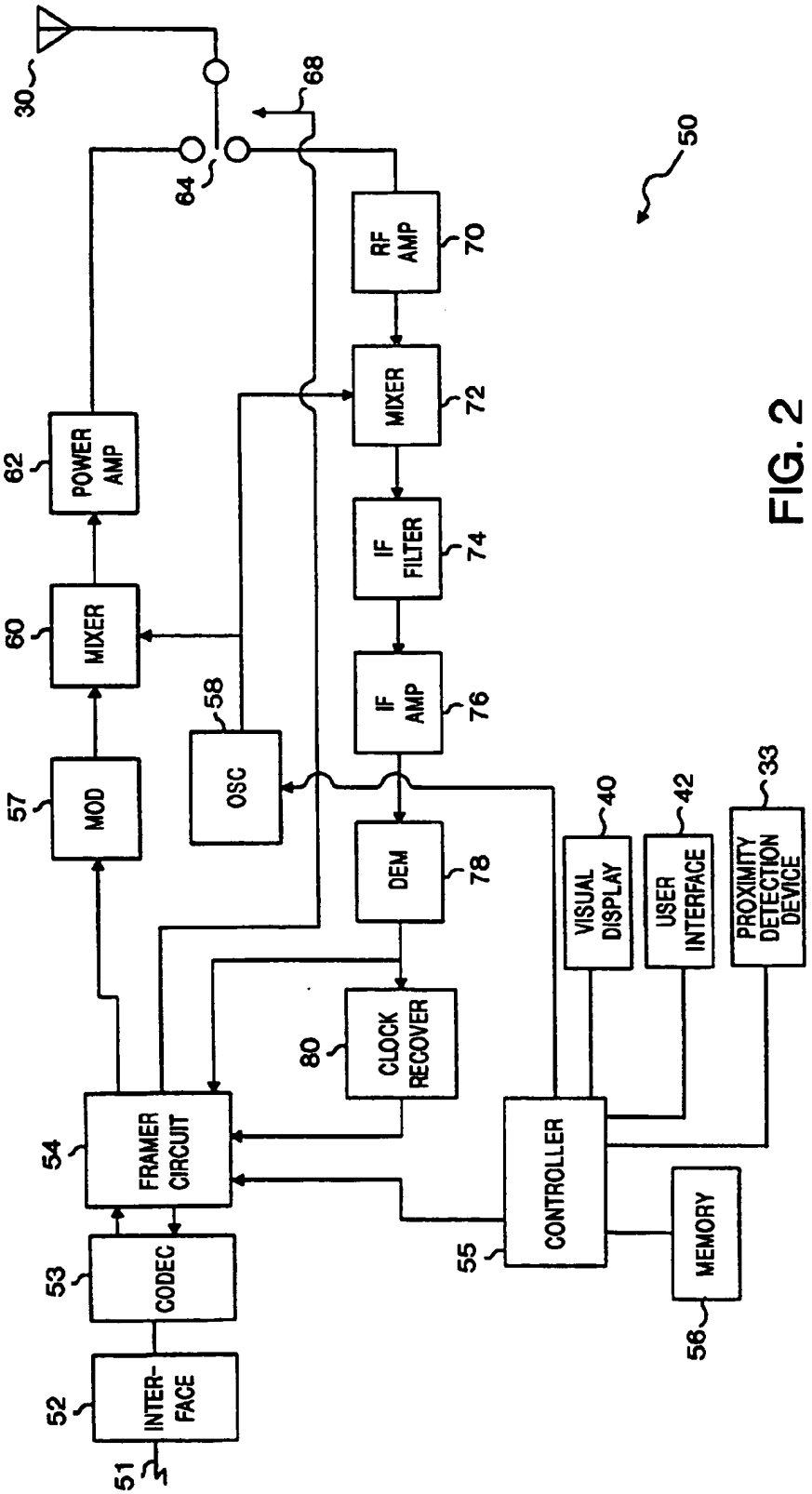

30
68
64
50
RF AMP
70
MIXER
72
IF FILTER
74
IF AMP
76
DEM
78
62
POWER AMP
60
MIXER
58
OSC
57
MOD
80
CLOCK RECOVER
54
FRAMER CIRCUIT
53
CODEC
52
INTER-FACE
51
55
CONTROLLER
40
VISUAL DISPLAY
42
USER INTERFACE
33
PROXIMITY DETECTION DEVICE
56
MEMORY

FIG. 2

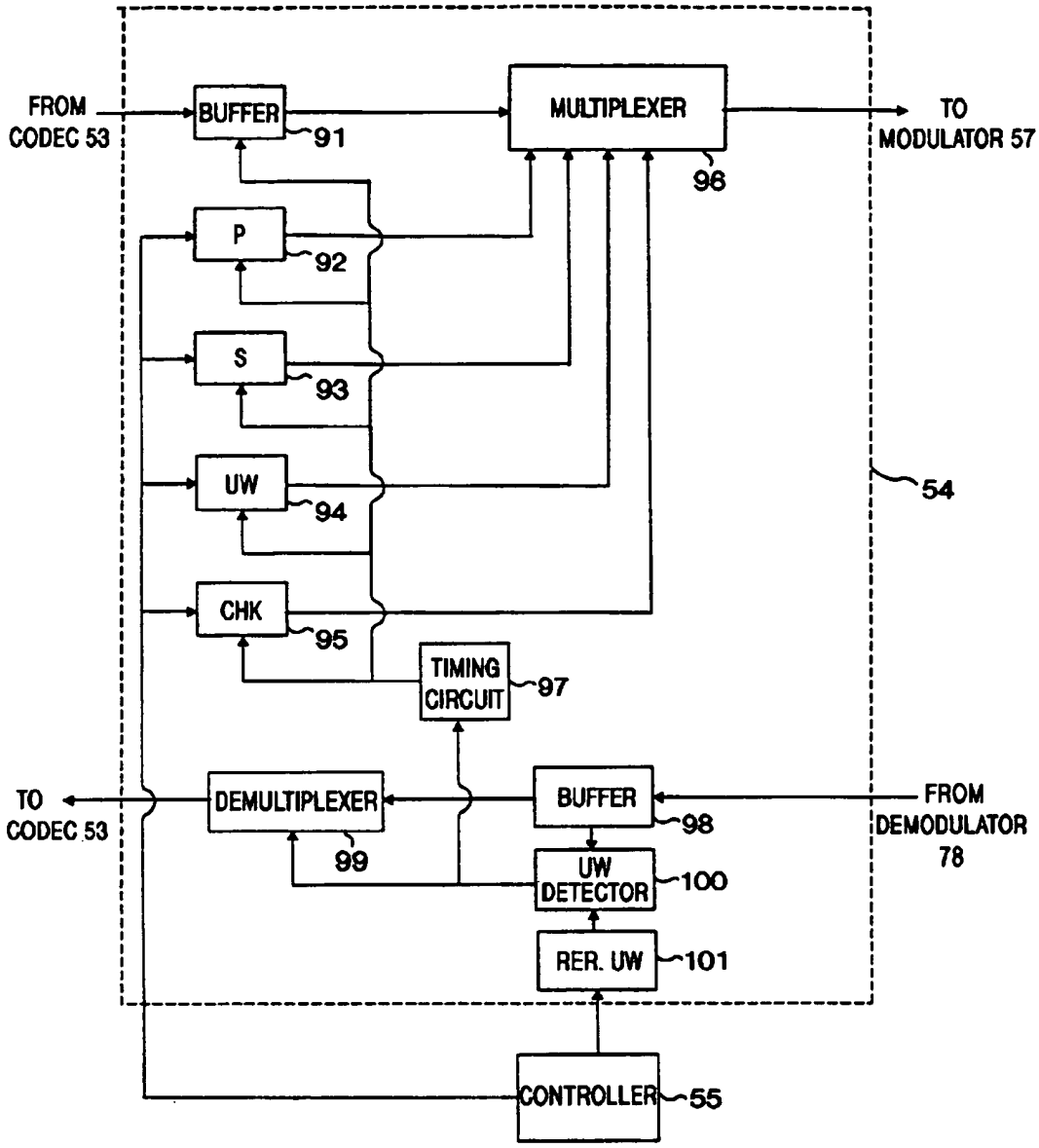

FROM CODEC 53
BUFFER
91
MULTIPLEXER
96
TO MODULATOR 57
P
92
S
93
UW
94
CHK
95
54
TIMING CIRCUIT
97
TO CODEC 53
DEMULTIPLEXER
99
BUFFER
98
FROM DEMODULATOR 78
UW DETECTOR
100
RER. UW
101
CONTROLLER
55

FIG. 3

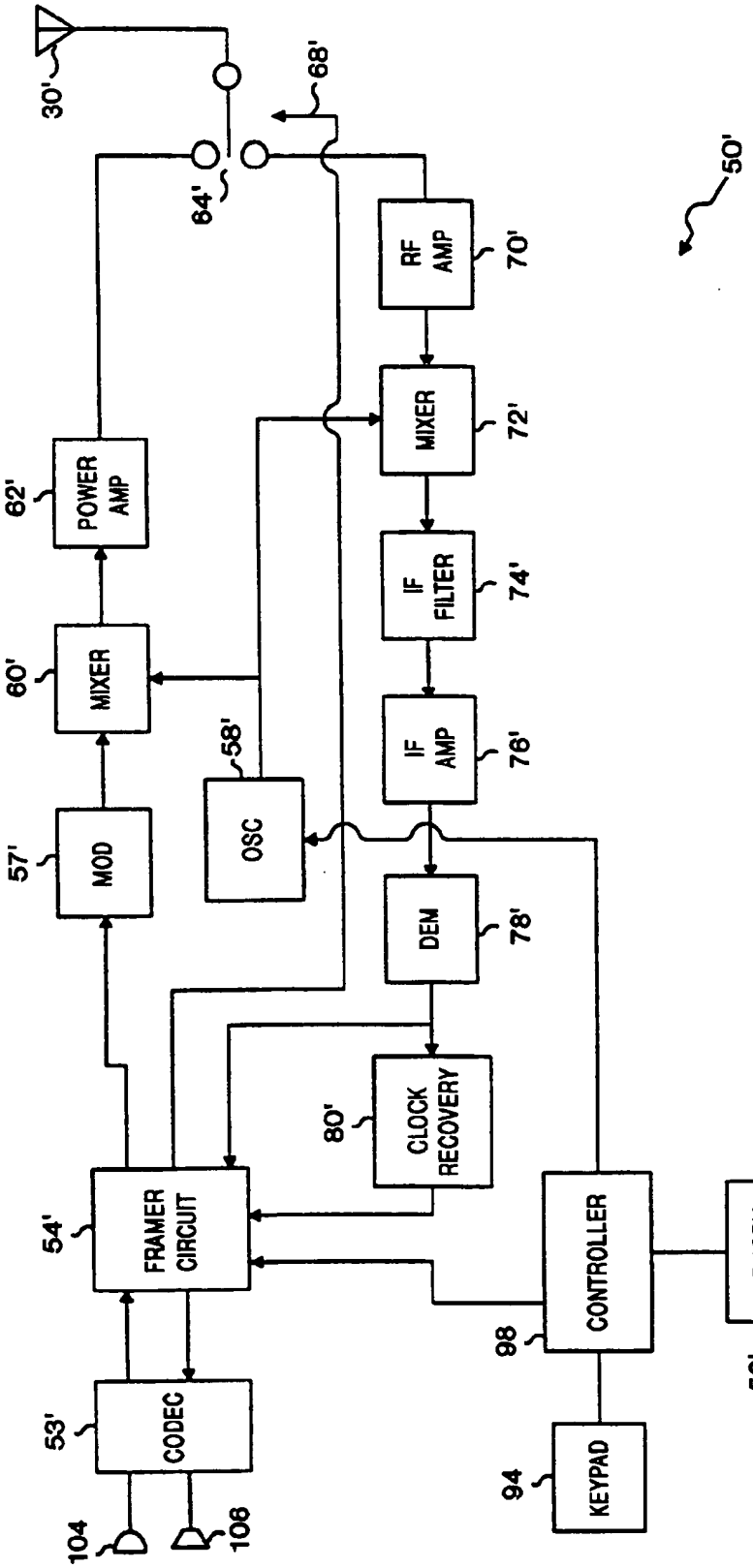

30'
68'
64'
50'
RF AMP
70'
MIXER
72'
IF FILTER
74'
IF AMP
76'
DEM
78'
CLOCK RECOVERY
80'
POWER AMP
62'
MIXER
60'
MOD
57'
OSC
58'
FRAMER CIRCUIT
54'
CODEC
53'
104
106
CONTROLLER
98
MEMORY
56'
KEYPAD
94

FIG. 4

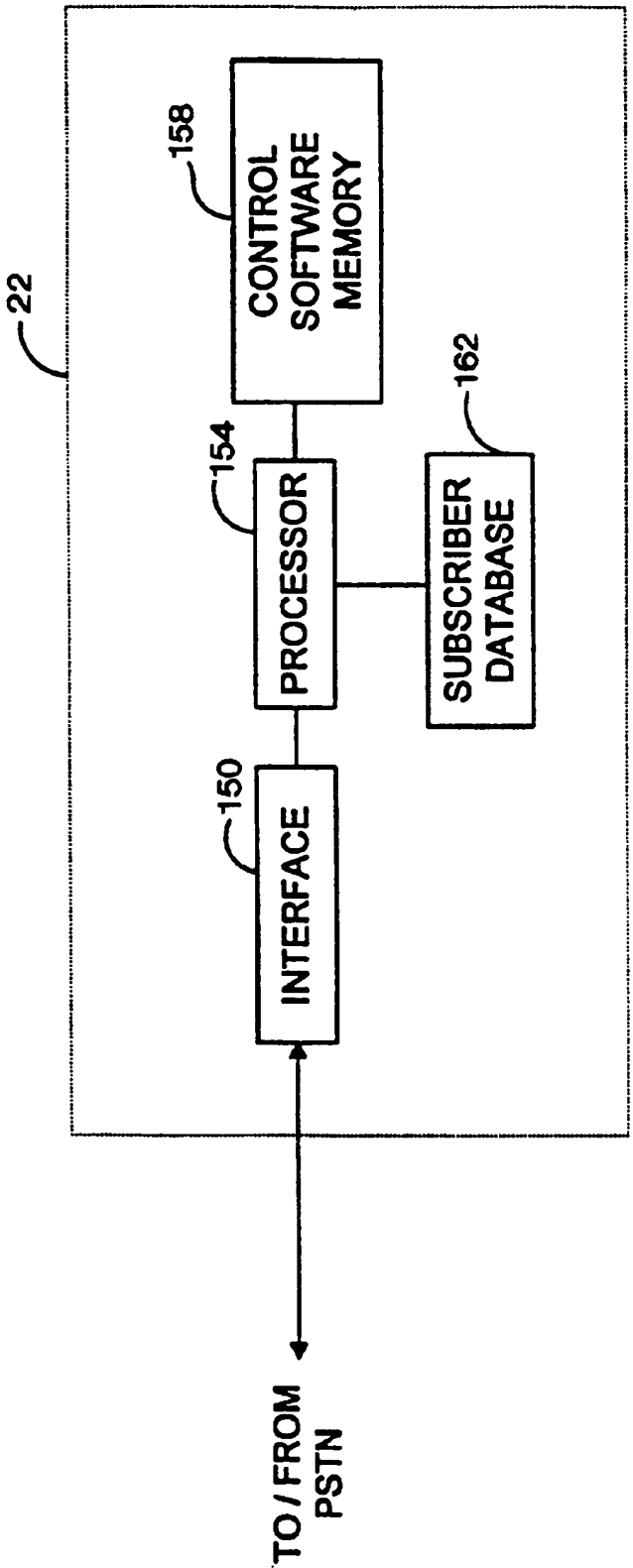

22
158
CONTROL SOFTWARE MEMORY
154
PROCESSOR
162
SUBSCRIBER DATABASE
150
INTERFACE
TO / FROM PSTN

FIG. 5

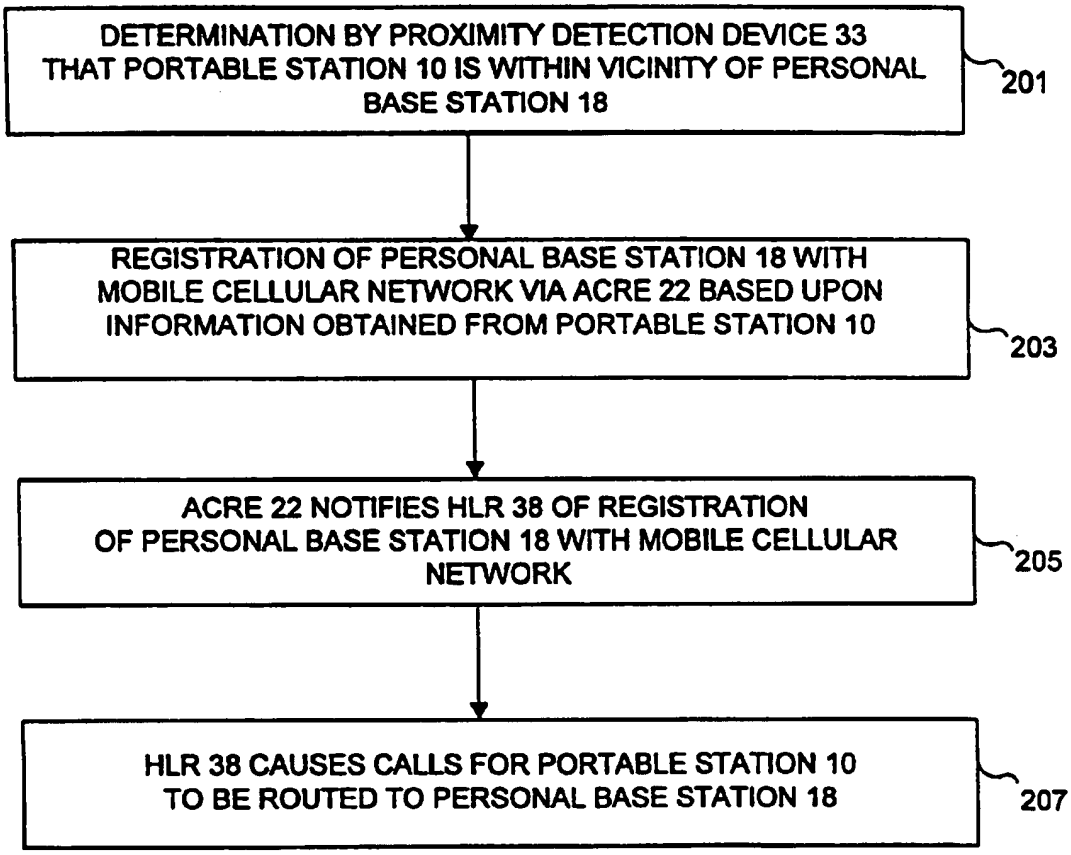

DETERMINATION BY PROXIMITY DETECTION DEVICE 33 THAT PORTABLE STATION 10 IS WITHIN VICINITY OF PERSONAL BASE STATION 18
201
REGISTRATION OF PERSONAL BASE STATION 18 WITH MOBILE CELLULAR NETWORK VIA ACRE 22 BASED UPON INFORMATION OBTAINED FROM PORTABLE STATION 10
203
ACRE 22 NOTIFIES HLR 38 OF REGISTRATION OF PERSONAL BASE STATION 18 WITH MOBILE CELLULAR NETWORK
205
HLR 38 CAUSES CALLS FOR PORTABLE STATION 10 TO BE ROUTED TO PERSONAL BASE STATION 18
207

FIG. 6

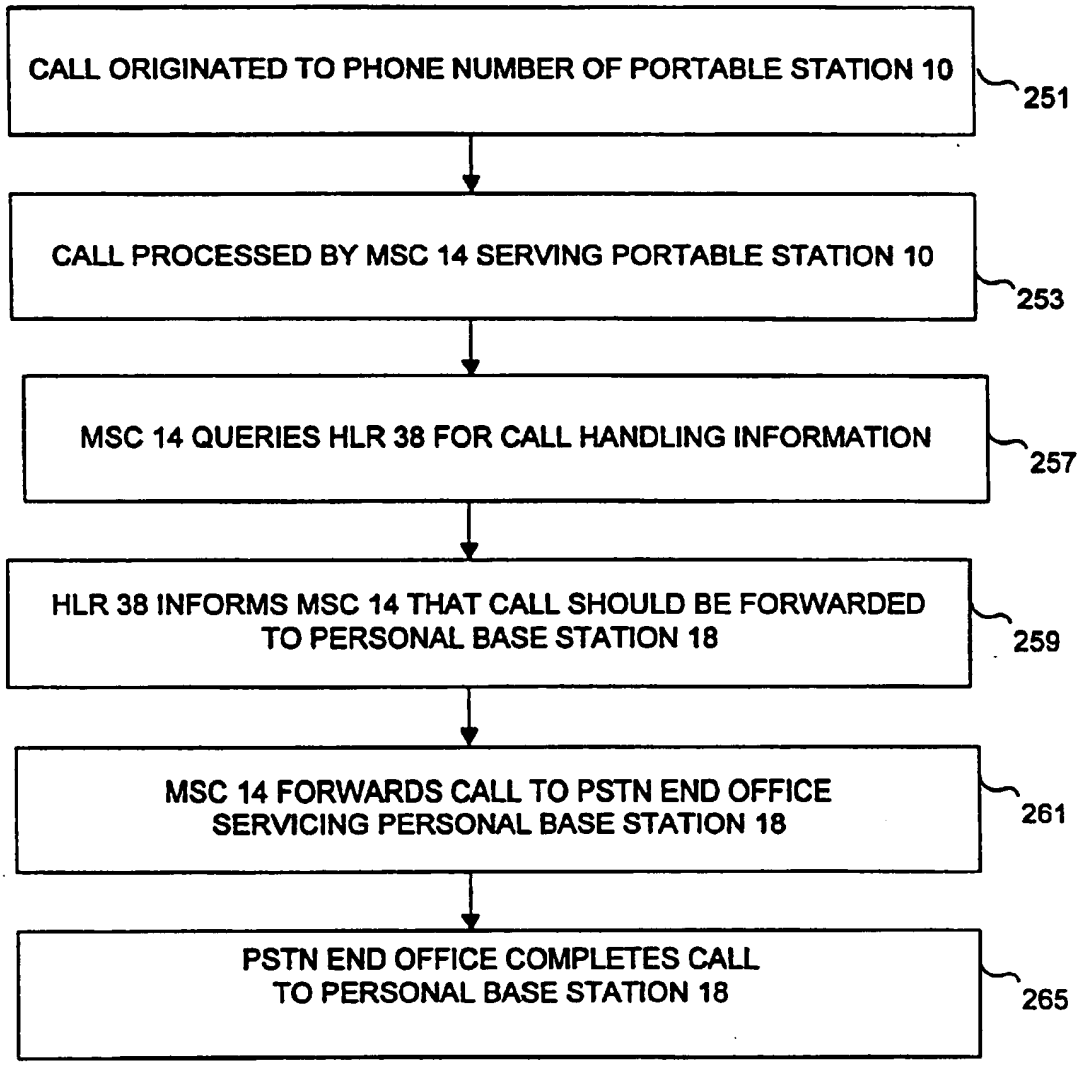

CALL ORIGINATED TO PHONE NUMBER OF PORTABLE STATION 10
251
CALL PROCESSED BY MSC 14 SERVING PORTABLE STATION 10
253
MSC 14 QUERIES HLR 38 FOR CALL HANDLING INFORMATION
257
HLR 38 INFORMS MSC 14 THAT CALL SHOULD BE FORWARDED TO PERSONAL BASE STATION 18
259
MSC 14 FORWARDS CALL TO PSTN END OFFICE SERVICING PERSONAL BASE STATION 18
261
PSTN END OFFICE COMPLETES CALL TO PERSONAL BASE STATION 18
265

FIG. 7

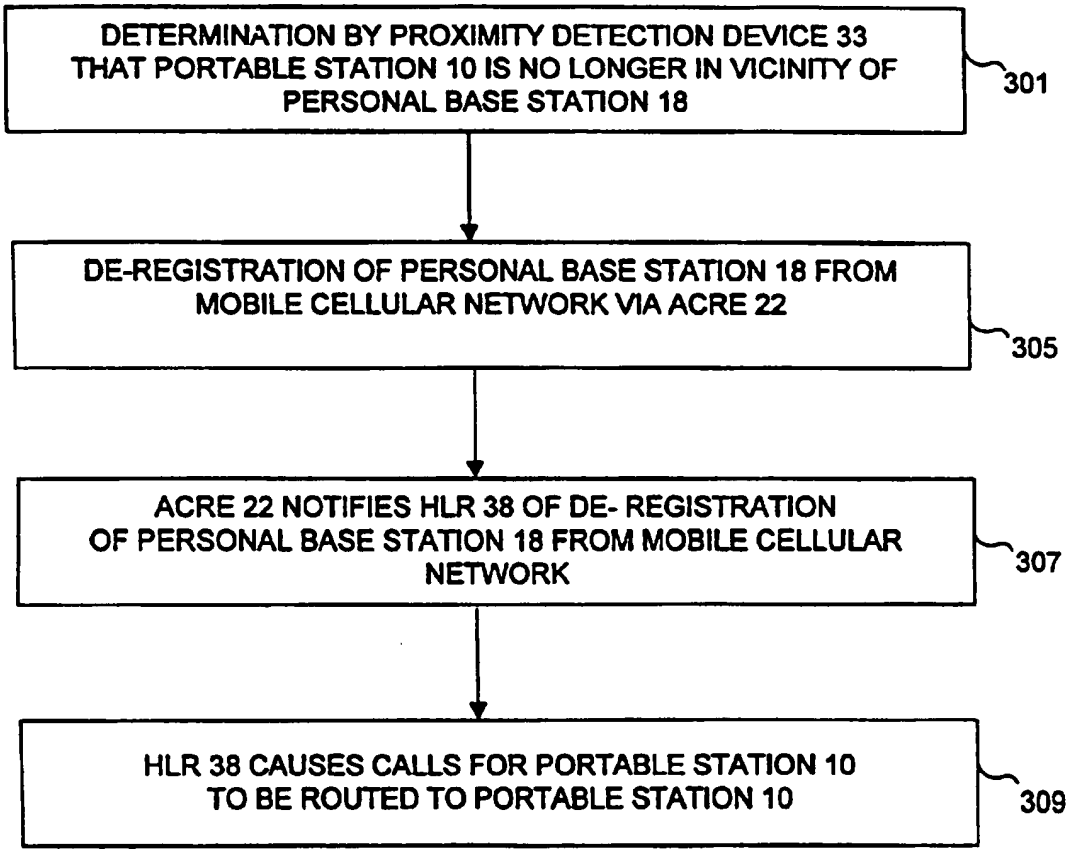

DETERMINATION BY PROXIMITY DETECTION DEVICE 33 THAT PORTABLE STATION 10 IS NO LONGER IN VICINITY OF PERSONAL BASE STATION 18
301
DE-REGISTRATION OF PERSONAL BASE STATION 18 FROM MOBILE CELLULAR NETWORK VIA ACRE 22
305
ACRE 22 NOTIFIES HLR 38 OF DE- REGISTRATION OF PERSONAL BASE STATION 18 FROM MOBILE CELLULAR NETWORK
307
HLR 38 CAUSES CALLS FOR PORTABLE STATION 10 TO BE ROUTED TO PORTABLE STATION 10
309

FIG. 8

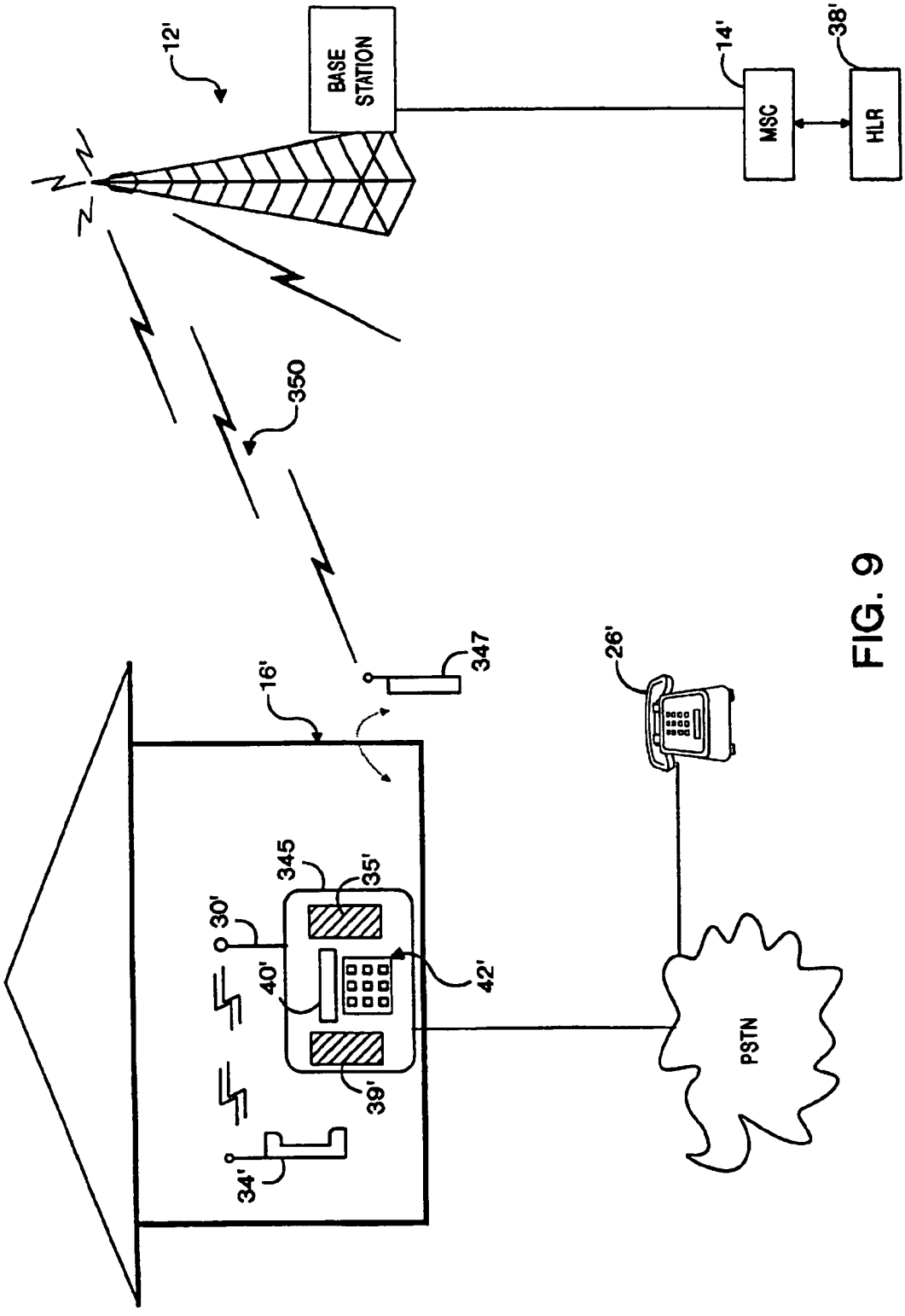

12'
BASE STATION
14'
MSC
38'
HLR
350
347
16'
26'
345
35'
30'
40'
42'
39'
34'
PSTN

FIG. 9

PERSONAL BASE STATION FOR INTEGRATED CELLULAR AND CORDLESS COMMUNICATION SYSTEM

BACKGROUND OF THE INVENTION

I. Field of the Invention

The present invention relates generally to the field of communication networks, and particularly to systems and methods for integrating portable cellular service with landline telephone service.

II. Description of the Related Art

A wide variety of options are available for enhancing home or office telephone systems. For example, constraints on mobility arising from the limited length of telephone cords can be overcome through the purchase a cordless telephone. This enables an increase in roaming range, which can be extended to a virtually unlimited extent through the additional purchase of a cellular telephone. However, the relatively higher cost for cellular air time creates an incentive to have a cordless telephone for home use and a cellular telephone for use outside of the home.

A cordless telephone system typically includes a portable cordless handset and a cordless base station connected to a telephone company phone system by telephone landlines. The cordless base station has an assigned landline telephone number that allows the user to place and receive calls using the cordless portable handset within a limited range of the cordless base station, such as in a home.

As mentioned above, wireless communication outside of the range of the cordless telephone system may also be provided via a cellular telephone system. A cellular telephone system typically includes portable subscriber stations and cellular base stations connected to the landline telephone system by way of one or more cellular switching networks. Each cellular subscriber unit has an assigned cellular telephone number that allows calls to be made and received throughout the area covered by base stations operated by the applicable service provider and its affiliated providers.

It has been found that difficulties tend to arise when a user frequently relocates between the nominal domains of the cordless and cellular telephone systems. For example, incoming calls routed through the cellular system may be missed when the user is at home, and incoming calls routed to the user's landline telephone number may be missed when the user is outside of the home.

Efforts to address these difficulties have been directed to the development of handsets capable of operating as standard cellular radiotelephones and also as cordless (or microcellular) telephones when within range of an associated cordless (or microcellular) base station. For example, U.S. Pat. No. 5,488,649, entitled "METHOD FOR VALIDATING A COMMUNICATION LINK", issued Jan. 30, 1996, describes a cordless communication system incorporating a portable cellular cordless ("PCC") radiotelephone. The PCC has the ability to communicate with a conventional cellular radiotelephone system, with a microcellular base station, or a cordless base station. The cordless communication system uses authorization and call routing equipment to provide call routing information to a telephone switching system disposed to automatically route calls between the cellular, microcellular, and cordless systems. In addition, U.S. Pat. No. 5,594,782, entitled "MULTIPLE MODE PERSONAL WIRELESS COMMUNICATION SYSTEM", issued Jan. 14, 1997, describes a system in which handsets automatically switch between a standard cellular telephone radiotelephone mode of operation and an enhanced cordless mode when within range of picocells located at customer-selected locations. Unfortunately, implementation of such "dual-mode" systems may often be impractical due to the relatively high cost of dual-mode handsets and the increased system complexity arising from the addition of specialized call routing equipment.

Another proposal to facilitate integration of wireless (e.g., cellular or PCS) and wireline communication networks involves utilization of a subscriber personal base station to originate a call to the wireless network when the subscriber's cellular/PCS device is within range of the of the personal base station. Such a technique is described in, for example, PCT Application Number PCT/US96/19879, which was published Jul. 3, 1997 under International Publication Number WO 97/24004, the disclosure of which is herein incorporated by this reference. Such proposals contemplate that the call originated by the personal base station results in the wireless network being instructed to route all cellular/PCS calls to the subscriber's landline phone number when the cellular/PCS device is detected as being within range of the personal base station. Specifically, the call originated by the personal base station is directed to a new network element at a mobile switching center that answers the call, collects the necessary information, emulates a visitors location register ("VLR") and originates a registration notification to a subscribers home location register ("HLR"). When registered, the call will result in the HLR querying the new network element or special VLR for re-routing information on all subsequent calls made to the subscriber's cellular number. The special VLR will respond to the HLR by re-routing such subsequent calls to the subscriber's landline telephone number.

One disadvantage of the foregoing proposal is the requirement that a user generally possess at least a personal base station, a landline telephone and a cellular telephone. If the user does not desire to, for example, continue to posses a landline telephone upon acquiring a personal base station, then when the user leaves the location which would otherwise be served by the landline telephone (e.g., the user's home) such location is left without telephone service. Accordingly, the user is required to purchase all three of the devices listed above or accept the consequences of having only intermittent phone service available at home or office locations. Moreover, the personal base stations currently being considered for development in connection with the foregoing proposal generally utilize a wireless communication link to obtain identification information concerning the subscriber's cellular/PCS device when such device is determined to be within radio range of the personal base station. This results in an appreciable increase in cost, since the personal base station is required to incorporate a dedicated radio transceiver simply for detecting and/or obtaining information from the subscriber's cellular/PCS device.

Thus there exists a need for a system capable of further improving integrated wireless and landline telephone service in a cost effective manner, and which preferably eliminates the need for acquisition of a separate landline telephone, personal base station, and cellular/PCS telephone.

SUMMARY OF THE INVENTION

The present invention is directed to an integrated cellular and cordless communication system in which cellular calls are forwarded to a landline telephone number associated

with a personal base station when a subscriber terminal is determined to be within a predefined vicinity of the personal base station. Once forwarded to the personal base station by way of call routing equipment in the external network, such calls may be answered using a cordless device operative to communicate with the personal base station. Alternately, the calls may be transferred to a voice messaging module within the personal base station. When the subscriber terminal is determined to have been removed from within the vicinity of the personal base station, a message from the personal base station to the external network results in the call forwarding address being modified such that subsequent calls intended for the subscriber terminal are in fact routed thereto. The personal base station may also be optionally implemented to enable the forwarding of calls intended for the personal base station to the subscriber terminal. A user could indicate the desire to initiate this type of call forwarding by way of, for example, a user interface of the personal base station. In response, the personal base station would inform the external network of the desire to initiate call forwarding, which would result in the forwarding to the subscriber terminal of subsequent landline calls intended for the personal base station.

BRIEF DESCRIPTION OF THE DRAWINGS

For a better understanding of the features, objects, and advantages of the present invention, reference should be made to the following detailed description taken in conjunction with the following drawings, in which:

FIG. **1** shows an integrated cellular and cordless communication system incorporating the personal base station of the present invention.

FIG. **2** is a block diagram of the personal base station, and depicts with particularity the elements included within a transceiver module therein.

FIG. **3** provides a detailed representation of a framer circuit included within the personal base station of the present invention.

FIG. **4** is a block diagram of a cordless station disposed to communicate with the personal base station.

FIG. **5** provides a block diagram representation of authentication and call routing equipment ("ACRE") disposed to perform authentication and call routing operations.

FIG. **6** is a flow chart depicting an exemplary process for registration of a subscriber terminal as being within a predetermined vicinity of the personal base station.

FIG. **7** is a flow chart depicting the call termination process occurring when a subscriber terminal is within a predefined vicinity of the personal base station and a call is placed to the subscriber terminal.

FIG. **8** provides a flow chart illustrating the process by which the personal base station is de-registered from the mobile cellular network following removal of the subscriber terminal from the vicinity of the personal base station.

FIG. **9** shows an integrated cellular and cordless communication system incorporating a personal base station of the present invention in which a wireless communication link is utilized to initiate call forwarding in accordance with the present invention.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

Referring to FIG. **1**, a conventional (except as otherwise described herein) cellular radiotelephone **10**, or "subscriber terminal **10**", is served by a mobile cellular network having a base station **12** and a mobile switching center ("MSC") **14**. The subscriber terminal **10** is operated by a subscriber having, for example, a home location **16** including a personal base station **18** configured in accordance with the present invention. The personal base station **18** is coupled through the public switched telephone network ("PSTN") to authorization and call routing equipment ("ACRE") **22** linked to the MSC **14** of the mobile cellular network. The PSTN includes end offices (not shown) capable of providing the personal base station **18** and another telephone **26** with wireline plain old telephone service (POTS). As is described below, the personal base station **18** includes a wireless interface (FIG. **2**) and an associated antenna **30** for collectively facilitating communication with a cordless station **34**. When cordless station **34** is not in use, it may be placed in docking bay **39** of the personal base station **18**. As is described hereinafter, the personal base station **18** is disposed to cooperate with network elements in the PSTN and the mobile cellular networks to enable the selective forwarding of calls intended for the subscriber terminal **10** to the cordless station **34**, and vice-versa.

In order for the cordless station **34** to communicate with the personal base station **18** it must generally be authorized to use a particular channel. Authorization is required since the licensee is of the applicable spectrum is required by the FCC to maintain control of its transmitters. The personal base station **18** may be programmed in a conventional manner to update its authorization periodically. To do this the personal base station **18** initiates a standard telephone call to the ACRE **22**. The ACRE **22** responds with a connect message containing a first random number that will be used in the authentication process. The personal base station **18** responds with an authentication message containing a cordless base station ID, a first authentication result calculated using the first random number, and a second random number. The ACRE **22** responds with an authorization and authentication message, which contains a second authentication result calculated using the second random number, and information describing over which channels the personal base station **18** can communicate with the cordless station **34**. A detailed description of the authentication process effectuated through the ACRE **22** is set forth in U.S. Pat. No. 5,488,469, entitled "METHOD FOR VALIDATING A COMMUNICATION LINK", issued Jan. 30, 1996, the disclosure of which is herein incorporated by this reference.

When the subscriber terminal **10** is detected to be within a predefined range or the personal base station **18**, or placed in direct contact with the docking bay **35**, the personal base station **18** provides a registration message to the ACRE **22**. The registration message includes the mobile identification number ("MIN") of the subscriber terminal **10**, and requests the ACRE **22** to configure the mobile wireless network to route all cellular calls intended for the subscriber terminal **10** to the landline phone number associated with the personal base station **18**. The ACRE **22** then effectively emulates a visitors location register ("VLR"), and originates a registration notification to a home location register ("HLR") **38** of the personal base station **18**. When calls are subsequently made to the cellular number of the subscriber terminal **10**, the HLR **38** will query the ACRE **22** for call re-routing information. In a preferred implementation of the present invention, this re-routing information will specify that calls intended for the subscriber terminal **10** be routed to the telephone number assigned to the personal base station **18**. The ACRE **22** will respond to the HLR **38** by providing re-routing information such that subsequent calls to the

subscriber terminal **10** are re-routed to the telephone number of the personal base station **18**. These re-routed calls may be answered upon removal of the cordless station **34** from the docking bay **39** or transferred to a voice messaging module (not shown) within the personal base station **18**.

The personal base station **18** also provides a message (via a telephone call) to the ACRE **22** to de-activate the call forwarding described above when the subscriber terminal **10** is moved outside of the predefined vicinity of, or out of direct contact with, the personal base station **18**. Also included in the personal base station **18** is a visual display **40** to indicate that call-forwarding is, or is not, re-directing calls from the subscriber terminal **10** to the personal base station **18**, or vice-versa (described below).

The personal base station **18** may optionally be implemented to originate a standard telephone call to the external wireless network when it is desired to forward calls intended for the personal base station **18** to the subscriber terminal **10**. In a preferred implementation a subscriber would indicate this intention to the personal base station **18** via a user interface **42**, at which point the personal base station **18** would inform the external wireless network (via the PSTN) of the desire to initiate call forwarding. Alternately, the external wireless network would only be requested to initiate such call forwarding when the subscriber terminal was not detected to be within a predefined vicinity of the personal base station **18**, or docked within docking bay **35**. The call originated by the personal base station **18** would request that the external wireless network ensure that all landline calls intended for the personal base station **18** are routed to the subscriber terminal **10** via the external wireless network.

The personal base station **18** may include either a conventional infra-red proximity detection device **33** (FIG. **2**), or a device responsive to physical contact with the docking bay **35**, to detect that the subscriber terminal **10** is within a predefined vicinity of, or docked in, the personal base station **18**. Information concerning the subscriber terminal **10** (e.g., mobile identification number "MIN"), may be directly transferred to the personal base station **18** from the subscriber terminal when the subscriber terminal **10** is placed within docking bay **35**. In this implementation the pertinent identification information may be transferred through a dedicated port in the subscriber terminal **10** which becomes coupled to a reciprocal port (not shown) in the docking bay **35** upon insertion of the subscriber terminal **10** in the docking bay **35**. Alternately, the identification information pertinent to the subscriber terminal **10** could initially be entered into and stored within the personal station **18** via the user interface **42**. The personal base station **18** could be configured or programmed such that one or more keys, buttons or icons of user interface **42** would become representative of a particular subscriber terminal **10**. Upon placing the subscriber terminal **10** into the docking bay **35**, the associated user would depress such one or more keys, buttons or icons and the associated identification information applicable to subscriber terminal **10** would be retrieved from within personal base station **18** and forwarded to ACRE **22** in the subsequent registration call.

FIG. **2** is a block diagram of the personal base station **18**, which depicts with particularity the elements included within a transceiver module **50**. The transceiver module **50** is substantially similar to a corresponding transceiver within the cordless station **34**, and particular realizations of both are described in U.S. Pat. No. 5,434,905, entitled "DIGITAL CORDLESS TELEPHONE SET OPERATED UNDER BURST SYNCHRONIZATION", issued Jul. 18, 1995, assigned to Uniden Corporation, the disclosure of which is herein incorporated by this reference. In FIG. **2**, the analog voice signal from a telephone network line **51** provided through an interface **52** is changed to a digital voice signal by the voice CODEC **53**. Certain preamble data, status data and check bits are then added serially to the digital voice signal by a framer circuit **54**, which may be implemented using a multiplexor/demultiplexor. The framer circuit **54**, under the direction of a controller **55**, also adds a "unique word" to the digital voice signal including both frequency channel information bits and fixed pattern bits (both described below).

The frequency channel information bits of the unique word provided to the framer circuit **54** are indicative of the frequency used to communicate between the cordless station **34** and the personal base station **18**, and the pattern of these bits is different for each frequency channel. On the other hand, the pattern of the fixed pattern bits is the same for all frequency channels. The frequency channel information bits in each frequency channel are determined by the frequency channel information stored for each channel in memory **56**.

When the personal base station **18** initiates communication with the cordless station **34**, the controller **55** reads, from the memory **56**, the frequency channel information corresponding to the frequency channel to be used in such communication. The controller **55** then sends such information to the framer circuit **54**. The framer circuit **54** sets the value of the unique word based on the frequency channel information sent from the controller **16**, and outputs baseband transmission data to a modulator **57**.

Since communication between the personal base station **18** and the cordless station **34** is nominally time division duplex ("TDD"), the baseband transmission data generated by the framer circuit **54** occupies one-half of the TDD burst frame cycle with the other-half of the burst frame cycle being used for reception. The baseband transmission data is modulated by the modulator **57**, heterodyned up to the RF frequency with the local oscillator signal from the local oscillator **58** by a mixer **60**, and then amplified by a radio frequency (RF) power amplifier **62**. Finally, the RF signal goes through the antenna switch **64** and is transmitted from the antenna **30**. The antenna switch **64** is interchangeably switched between transmitting and receiving modes in response to a TX/RX control signal **68**, which is generated by the framer circuit **54** based upon frame synchronization.

During the receive half cycle of each TDD burst frame, the signal received by the antenna **30** goes through the antenna switch **64** and is amplified by the front-end amplifier **70**. The amplified received signal is then mixed with a local oscillator signal from the local oscillator **58** in a mixer **72** to produce an intermediate frequency (IF) signal. The IF signal is filtered by an IF filter **74** and amplified by an IF amplifier **76**. The amplified IF signal is provided to a demodulator **78** which demodulates the IF signal so as to recover the baseband receive data. The recovered baseband data is then provided by the demodulator **78** to the framer circuit **54** and to the clock recovery circuit **80**.

The framer circuit **54** detects the unique word from the baseband receive data, and compares the frequency information included therein to the frequency actually being received. If the framer circuit **54** determines that the correct frequency has been received, then the clock recovery circuit **80** is utilized to establish frame synchronization. In an exemplary implementation the clock recovery circuit **80** is disposed to recognize a predefined bit pattern in the preamble of the baseband receive data, and to provide a synchronized bit clock to the framer circuit **54** upon making

such recognition. Once frame synchronization is established, the recovered digital voice signal is processed by the framer circuit **54** in accordance with the recovered clock signal provided by the clock recovery circuit **80**. The recovered digital voice signal produced by the framer circuit **54** is provided to the CODEC **53**, which converts the recovered digital voice signal into an analog voice signal for transmission on the telephone network line **51** via the interface **52**.

FIG. **3** provides a more detailed representation of the framer circuit **54** of the personal base station **18**, it being understood that the framer circuit **54'** of the cordless station **34** is substantially identical in structure and operation. The transmitting section of the framer circuit **54** includes a buffer **91**, a preamble bit generator **92**, a status bit generator **93**, a unique word generator **94**, a check bit generator **95**, a multiplexor **96** and a timing circuit **97**. The receiving section of the framer circuit **54** comprises a buffer **98**, a demultiplexor **99** and a unique word detector **100**.

While the frame buffer **54** is in a transmission mode, voice data from the CODEC **53** is initially stored in buffer **91**. The voice data from the buffer **91**, the preamble bits from the preamble bit generator **92**, the status bits from the status bits generator **93**, the unique word from the unique word generator **94** and the check bits from the check bit generator **95** are multiplexed by a multiplexor **96** into a frame of data for transmission. During this multiplexing process the output timing of the buffer **91** and of the generators **92–95** are controlled by the timing circuit **97**. The timing circuit **97** is driven by a signaling pulse from the unique word detector **100**, the operation of which is described below.

During operation of the frame buffer **54** in a receive mode, the baseband data from the demodulator **78** is initially stored in buffer **98**. The data stored in the buffer **98** is then provided to the demultiplexor **99** and the unique word detector **100**. The unique word detector **100** detects the unique word inherent within the received baseband data and compares this detected unique word to a reference unique word stored in buffer **101**. The reference unique word is stored in buffer **101** by controller and corresponds to the unique word produced by the unique word generator **94**. When unique word detector **100** detects a "match" between the detected unique word and the reference unique word, the detector **100** provides a signaling pulse to the timing circuit **97** and to the demultiplexor **99**. Upon receipt of the signaling pulse from the unique word detector **100**, the demultiplexor **99** extracts the digital voice and control data from the received baseband data and forwards this extracted information to the CODEC **53**. In addition, the demultiplexor **99** extracts status bits from the received baseband data and provides these to the controller **55**.

FIG. **4** is a block diagram of the cordless station **34**, which depicts with particularity the elements included with a transceiver module **50'** disposed to facilitate communication with the personal base station **18**. In view of the substantial similarity between the transceiver module **50'** and transceiver module **50** (FIG. **2**), a detailed description of the operation of the cordless station **34** will not be provided herein and primed reference numerals will be used in FIG. **4** to identify elements substantially identical to corresponding elements in FIG. **2**. Referring to FIG. **4**, the cordless station **34** includes a microphone **104** and a speaker **106** in lieu of the interface **52** of FIG. **2**. The microphone **104** and the speaker **106** are connected to CODEC **53'** and the keypad **94** is connected to the controller **98**. The transceiver **50'** is operative to transmit and receive voice and data information transferred via the microphone **104** and the speaker **106** in the manner described above with reference to the interface **52**.

The subscriber terminal **10** could be realized by modifying a conventional wireless handset in a number of different ways to facilitate the transfer of identification information (e.g., MIN) to the personal base station **18** when the subscriber terminal **10** is docked therein. For example, a port or pin could be incorporated within the subscriber terminal **10** to facilitate electrical and mechanical coupling with the personal base station **18**. Such a port, or a pin-type structure, could also enable the subscriber terminal **10** to detect its insertion into the docking bay **35**, as well as allow the personal base station **18** to detect such insertion. The subscriber terminal **10** will preferably also be configured so that, upon such detection, it would enter an "offline" state during which communication with the external wireless network would be suspended.

Turning now to FIG. **5**, a block diagram of the ACRE **22** is shown in which connection to the PSTN is made through an interface **150**. The interface **150** controls and formats messages between the PSTN and a processor **154**. The processor **154** in combination with a control software memory **158** comprises the intelligence of the ACRE **22** and performs authorization and authentication tasks, and provides call routing information. A subscriber database **162** contains the data required by the processor **154** to perform the tasks discussed above. The ACRE **22** can be separate from the PSTN as shown in FIG. **1**, or can a part of switching equipment included therein.

In FIG. **6**, an exemplary process for registration of the subscriber terminal **10** as being proximate the personal base station **18** is presented in the form of a flow chart. As discussed above, this registration process occurs in response to the subscriber terminal **10** being within range or docked in the personal base station **18**. In an operation **201**, the proximity detection device **33** so detects the subscriber terminal **10** as being within range or docked in the personal base station **18**.

In an operation **203**, the personal base station **18** initiates the registration procedure after the proximity detection of operation **201**. In response, the personal base station **18** provides a registration message to the ACRE **22**. The registration message includes the MIN of the subscriber terminal **10**; a source address of the personal base station **18**; a destination address for the HLR assigned to the personal base station **18** and/or an identification number for call forwarding calls intended for the subscriber terminal **10** to the personal base station **18**. In operation **205**, the ACRE **22** notifies the HLR **38** of the registration of subscriber terminal **10** and the call forwarding number. In operation **207**, the HLR **38** recognizes the change in registration and transfers calls intended for the subscriber terminal **10** to the personal base station **18**.

FIG. **7** is a flow chart depicting the call termination process occurring when the subscriber terminal **10** is within range of, or docked within, the personal base station **18** and a call is made from telephone **26** (FIG. **1**) to the subscriber terminal **10**. In this case, the resulting call is forwarded to the landline telephone number associated with personal base station **18** and not to the subscriber terminal **10**. In an operation **251**, the call to the subscriber terminal **10** is originated by telephone **26**. In an operation **253**, the call traverses the PSTN to the MSC **14** (assumed to be the "home" MSC/VLR of subscriber terminal **10**) and call processing is initiated. In an operation **257**, the MSC **14** queries the HLR **38** (FIG. **1**) for call handling information. In this instance, the HLR **38** will have determined that the call is to be forwarded to the personal base station **18**.

In an operation **259**, the HLR **38** indicates to the MSC **14** that the call is to be forwarded to the personal base station

18 and in an operation 261 the MSC 14 forwards the call to an end office in the PSTN servicing the personal base station 18. In an operation 265, the end office completes the call to the personal base station 18.

FIG. 8 provides a flow chart illustrating the process by which the personal base station 18 is de-registered within the mobile cellular network following a selected time interval subsequent to removal of the subscriber terminal 10 from the vicinity of the personal base station 18. In such event the cellular calls intended for the subscriber terminal 10 are in fact directed to the subscriber terminal 10.

In an operation 301, the proximity device 33 determines that the portable base station 10 is no longer within range of, or docked within, the personal base station 18. In an operation 305, the personal base station 18 initiates de-registration from the cellular network. In particular, a message is sent to the ACRE 22 indicating this de-registration condition of the personal base station 18. In an operation 307, the ACRE 22 forwards this de-registration notification to the HLR 38. In response, the HLR 38 routes incoming calls intended for the subscriber terminal 10 directly thereto rather than to the personal base station 18 (operation 309).

The personal base station 18 could optionally be configured to cause calls placed to the personal base station 18 to be forwarded to the subscriber terminal 10. In particular, the personal base station 18 could be programmed such that, upon depression of a dedicated key or button of user interface 42, a predefined feature sequence would be sent to the landline carrier servicing the personal base station 18 via the PSTN. The predefined feature sequence would include a "feature code" (i.e., call forwarding) and the phone number associated with the subscriber terminal 10. As an example, in certain networks the predefined feature sequence "*70 5551212" would instruct the landline carrier to forward calls intended for the personal base station 18 to a telephone number "555-1212" associated with the subscriber terminal 10.

FIG. 9 shows an integrated cellular and cordless communication system which incorporates a personal base station 345 and in which a subscriber terminal 347 initiates and suspends call forwarding in accordance with the present invention. As is discussed below, call forwarding requests are provided to the external wireless network by the subscriber terminal 347 via a wireless communication link 350 rather than by the personal base station 345 in cooperation with an ACRE.. The personal base station 345 is substantially similar to the personal base station 18, but does not include elements for communicating through a landline connection with an ACRE. In FIG. 9, primed reference numerals will be used to identify elements substantially identical to corresponding elements in FIG. 1.

Referring to FIG. 9, when the subscriber terminal 347 detects that it is being placed in docking bay 35', the subscriber terminal 347 provides a "Deregistration" message to the base station 12'. The Deregistration message will be provided in the format required by the protocol applicable to the wireless communication link 350 (e.g., IS-136, GSM, or IS-95). Upon becoming docked within docking bay 35', the subscriber terminal 347 enters an inactive or "sleep" state and ceases active communication with the base station 12'. The Deregistration message includes the mobile identification number ("MIN") of the subscriber terminal 10', and unconditional call forwarding information instructing the external wireless network to route all cellular calls intended for the subscriber terminal 347 to the landline phone number associated with the personal base station 345. When calls are subsequently made to the cellular number of the subscriber terminal 347, the external wireless network will route such calls to the telephone number assigned to the personal base station 345. These re-routed calls may be answered upon removal of the cordless station 34' from the docking bay 39' or transferred to a voice messaging module (not shown) within the personal base station 345.

Upon detecting removal from the docking bay 35', the subscriber terminal 347 sends (via wireless communication link 350) a Registration message to the external wireless network which results in de-activation of the call forwarding described above. That is, subsequent calls to the subscriber terminal 347 are in fact directed thereto, rather than to the personal base station 345, by the external wireless network.

As described in the Background of the Invention, one disadvantage of certain proposals for cellular call-forwarding using a personal base station is that a user must possess at least a personal base station, a landline telephone and a cellular telephone. If the user does not desire to, for example, continue to posses a landline telephone upon acquiring a personal base station, then when the user leaves the location which would otherwise be served by the landline telephone (e.g., the user's home) such location is left without telephone service. In addition, the cost of many personal base stations currently being considered for development is increased through use of a wireless communication transceiver to procure information necessary for landline call forwarding from the subscriber's cellular/PCS device.

In summary, an integrated cellular and cordless communication system overcoming the disadvantages described above has been described in which cellular calls are forwarded to landline telephone number associated with a personal base station when a subscriber terminal is determined to be within a predefined vicinity of the personal base station. Once forwarded to the personal base station via ACRE, such calls may be answered using a cordless device operative to communicate with the personal base station. Alternately, the calls may be transferred to a voice messaging module within the personal base station. When the subscriber terminal is determined to have been removed from within the vicinity of the personal base station, a message from the personal base station to the ACRE results in the call forwarding address in the HLR being modified such that subsequent calls intended for the subscriber terminal are in fact routed thereto. The personal base station may also be optionally implemented to enable the forwarding of calls intended for the personal base station to the subscriber terminal 10. Specifically, a subscriber could indicate this intention through, for example, a user interface of the personal base station. In response, the personal base station would inform the ACRE of the desire to initiate call forwarding, and the applicable MSC and HLR would cooperate as described above to appropriately forward subsequent landline calls to the subscriber terminal.

The foregoing description, for purposes of explanation, used specific nomenclature to provide a thorough understanding of the invention. However, it will be apparent to one skilled in the art that the specific details are not required in order to practice the invention. In other instances, well known circuits and devices are shown in block diagram form in order to avoid unnecessary distraction from the underlying invention. Thus, the foregoing descriptions of specific embodiments of the present invention are presented for purposes of illustration and description. They are not intended to be exhaustive or to limit the invention to the precise forms disclosed, and clearly many modifications and

variations are possible in view of the above teachings. It is intended that the scope of the invention be defined by the following Claims and their equivalents.

We claim:

1. A personal base station capable of communication with an external network, said personal base station comprising:

means for determining when a subscriber terminal is within a predefined vicinity of said personal base station, said means for determining including a first docking bay for said subscriber terminal and a second docking bay for a cordless station;

means for transmitting a registration message to said external network in order that calls from said external network intended for said subscriber terminal are routed to a telephone number associated with said personal base station when said subscriber terminal is within said predefined vicinity; and

means for forwarding said calls to a cordless station in communication with said personal base station, said cordless station being physically distinct from said subscriber terminal.

2. A personal base station capable of communication with an external network, said personal base station including a first docking bay for a subscriber terminal and a second docking bay for a cordless station wherein said cordless station is physically distinct from said subscriber terminal, said personal base station comprising:

a transmitter operative to transmit a registration message to said external network in order that calls from said external network intended for said subscriber terminal are routed to a telephone number associated with said personal base station when said subscriber terminal is within a predefined vicinity of said personal base station;

a controller, operatively coupled to said transmitter, capable of forwarding said calls to said cordless station; and

a proximity detection device operatively coupled to said controller, said proximity detection device generating a detection signal when said subscriber terminal is within said predefined vicinity of said personal base station.

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